AIS-100

AUTOMOTIVE INDUSTRY STANDARD

Requirements for the Protection of Pedestrian and other Vulnerable Road Users in the event of a Collision with a Motor Vehicle

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ON BEHALF OF
AUTOMOTIVE INDUSTRY STANDARDS COMMITTEE
UNDER
CENTRAL MOTOR VEHICLE RULES – TECHNICAL STANDING COMMITTEE
SET-UP BY
MINISTRY OF ROAD TRANSPORT & HIGHWAYS
(DEPARTMENT OF ROAD TRANSPORT & HIGHWAYS)
GOVERNMENT OF INDIA

July 2010

Status chart of the Standard to be used by the purchaser for updating the record

Sr. No.	Corrigenda.	Amendment	Revision	Date	Remark	Misc.
General remarks :						

INTRODUCTION

The Government of India felt the need for a permanent agency to expedite the publication of standards and development of test facilities in parallel when the work of preparation of standards is going on, as the development of improved safety critical parts can be undertaken only after the publication of the standard and commissioning of test facilities. To this end, the erstwhile Ministry of Surface Transport (MoST) has constituted a permanent Automotive Industry Standard Committee (AISC) vide order no. RT-11028/11/97-MVL dated September 15, 1997. The standards prepared by AISC will be approved by the permanent CMVR Technical Standing Committee (CTSC). After approval, The Automotive Research Association of India, (ARAI), Pune, being the secretariat of the AIS Committee, has published this standard. For better dissemination of this information, ARAI may publish this document on their website.

1. The purpose of this standard is to bring about an improvement in the construction of the fronts of vehicles and, in particular, those areas which have been most frequently identified as causing injury when in collision with a pedestrian or other vulnerable road user. The tests required are limited to those elements of the child and adult body most frequently identified as sustaining injury, i.e. the adult head and leg and the child head. To achieve the required improvements in construction of vehicles, the tests are based on sub-system component impactors representing those body regions and impacted at speeds representative of that below which the majority of injuries occur.
2. The vehicles to be tested under the standard are representative of the majority of vehicles in circulation in the urban environment, where there is a greater potential for collision with pedestrians and other vulnerable road users, and include passenger cars, and light trucks.
3. Europe in 2003 had taken up 2 phase implementation of the pedestrian protection test standard. The intended phase 2 will now be GTR 9 requirements.
4. AIS-100 was discussed in AISC 30 and it was agreed to align the technical requirements in line with GTR 9 but scope to be aligned with 2003/102/EEC phase 1 for the following two reasons –
    - this is the first step into pedestrian protection requirements to understand the design, development, testing and certification modalities. India does not have any previous experience with these requirements.
    - the other category vehicles would face operational difficulties if made to comply with GTR.
5. The scope of the standard was discussed again in AISC 33 during Oct 09. Based on WP29 document ECE/TRANS/WP.29/GRSP/20, the FFV exemptions are extended to all M1 categories.

While preparing this standard considerable assistance is derived from following international standards:

Global Technical Regulation No. 9	Pedestrian Safety
EEC Directive 2003/102/EC, Repealed by Regulation (EC)/78/2009/EC & 631/2009/EC	Protection of Pedestrian & other Vulnerable Road User before & in the event of a Collsion with a Motor Vehicle

The AISC panel and the Automotive Industry Standard Committee (AISC) responsible for preparation of this standard is given in Annex C and Annex D respectively.

Requirements for the Protection of Pedestrian and other Vulnerable Road Users in the event of a Collision with a Motor Vehicle

Requirements for the Protection of Pedestrian and other Vulnerable Road Users in the event of a Collision with a Motor Vehicle

1. SCOPE

1.1 This standard applies to the frontal surfaces of the power driven vehicles of

1.1.1 Category M1 with GVW not exceeding 2500 kg,

1.1.2 category N1 (derived from the vehicle categories mentioned in 1.1.1 above) with GVW not exceeding 2500 kg,

1.2 The following vehicles are exempted from the scope of the standard :

1.2.1 vehicle of categories mentioned in 1.1 with GVW upto 500 kg

1.2.2 vehicles of categories mentioned in 1.1 where the distance, measured longitudinally on a horizontal plane, between the transverse centerline of the front axle & the R point of the driver's seat is less than 1100 mm.

2. REFERENCES

2.1 The following standards are necessary adjuncts to this standard

2.1.1	ISO 6487 : 2000 & ISO 6487 : 2002	Measurement Techniques in Impact Tests – Instrumentation
2.1.2	ISO 3784 : 1976	Road vehicles - Measurement of Impact Velocity in Collision Tests
2.1.3	AIS-053	Automotive Vehicles -Types - Terminology

3. DEFINITIONS

When performing measurements as described in this standard, the vehicle should be positioned in its normal ride attitude.

If the vehicle is fitted with a badge, mascot or other structure, which would bend back or retract under an applied load of maximum 100 N, then this load shall be applied before and/or while these measurements are taken.

Any vehicle component which could change shape or position, other than suspension components or active devices to protect pedestrians, shall be set to their stowed position.

For the purposes of this standard:

3.1 **"Adult headform test area"** is an area on the outer surfaces of the front structure. The area is bounded, in the front, by a wrap around distance of 1,700 mm and, at the rear, by the rear reference line for adult headform and, at each side, by the side reference line.

3.2 **"A-pillar"** means the foremost and outermost roof support extending from the chassis to the roof of the vehicle.

3.3 **"Bonnet leading edge"** means the edge of the front upper outer structure of the vehicle, including the bonnet & wings, the upper and side members of the headlight surrounds and any other attachments. The reference line identifying the position of the bonnet leading edge is defined by its height above the ground reference plane and by horizontal distance separating it from the bumper (bumper lead).

3.4 **"Bonnet leading edge height"** means, at any point on the bonnet leading edge, the vertical distance between the ground reference plane and bonnet leading edge reference line at that point.

3.5 **"Bonnet leading edge reference line"** means the geometric trace of the points of contact between a straight edge 1,000 mm long and the front surface of the bonnet, when the straight edge, held parallel to the vertical longitudinal plane of the car and inclined rearwards by 50° from the vertical and with the lower end 600 mm above the ground, is traversed across and in contact with the bonnet leading edge (see Figure 1).

For vehicles having the bonnet top surface inclined at 50°, so that the straight edge makes a continuous contact or multiple contacts rather than a point contact, determine the reference line with the straight edge inclined rearwards at an angle of 40° from the vertical.

For vehicles of such shape that the bottom end of the straight edge makes first contact with the vehicle then that contact is taken to be the bonnet leading edge reference line, at that lateral position.

For vehicles of such shape that the top end of the straight edge makes first contact with the vehicle then the geometric trace of 1,000 mm wrap around distance, will be used as bonnet leading edge reference line at that lateral position.

The top edge of the bumper shall also be regarded as the bonnet leading edge if it is contacted by the straight edge during this procedure.

3.6 **"Bonnet rear reference line"** means the geometric trace of the most rearward points of contact between a 165 mm diameter sphere and the front structure of the vehicle when the sphere is traversed across the front structure of the vehicle while maintaining contact with the windscreen (see Figure 2). The wiper blades & arms are removed during this process.

Where the bonnet rear reference line and the side reference line do not intersect, the bonnet rear reference line should be extended and/or modified using a semi-circular template, of radius 100 mm. The template should be made of a thin flexible sheet material that easily bends to a single curvature in any direction. The template should, preferably, resist double or complex curvature where this could result in wrinkling. The recommended material is a foam backed thin plastic sheet to allow the template to "grip" the surface of the vehicle. The template should be marked up with four points "A" through "D", as shown in Figure 3, while the template is on a flat surface.

The template should be placed on the vehicle with Corners "A" and "B" coincident with the side reference line. Ensuring these two corners remain coincident with the side reference line, the template should be slid progressively rearwards until the arc of the template makes first contact with the bonnet rear reference line. Throughout the process, the template should be curved to follow, as closely as possible, the outer contour of the vehicle's bonnet top, without wrinkling or folding of the template. If the contact between the template and bonnet rear reference line is tangential and the point of tangency lies outside the arc scribed by points "C" and "D", then the bonnet rear reference line is extended and/or modified to follow the circumferential arc of the template to meet the bonnet side reference line, as shown in Figure 4.

If the template cannot make simultaneous contact with the bonnet side reference line at points "A" and "B" and tangentially with the bonnet rear reference line, or the point at which the bonnet rear reference line and template touch lies within the arc scribed by points "C" and "D", then additional templates should be used where the radii are increased progressively in increments of 20 mm, until all the above criteria are met.

3.7 **"Bonnet top"** is the area which is bounded by (a), (b) and (c) as follows:

(a) the bonnet leading edge reference line;

(b) the bonnet rear reference line;

(c) the side reference lines.

3.8 **"Bumper"** means the front, lower, outer structure of a vehicle. It includes all structures that are intended to give protection to a vehicle when involved in a low speed frontal collision and also any attachments to this structure. The reference height and lateral limits of the bumper are identified by the corners and the bumper reference lines.

3.9 **"Bumper lead"** means for any longitudinal section of a vehicle, the horizontal distance in the vehicle longitudinal plane between the upper bumper reference line and the bonnet leading edge reference line.

3.10 **"Bumper test area"** means the frontal surface of the bumper limited by two longitudinal vertical planes intersecting the corners of the bumper and moved 66 mm parallel and inboard of the corners of the bumpers.

3.11 **"Centre of the knee"** of the lower legform impactor is defined as the point about which the knee effectively bends.

3.12 **"Child headform test area"** is an area on the outer surfaces of the front structure. The area is bounded, in the front, by the front reference line for child headform, and, at the rear, by the WAD1700 line, and by the side reference lines.

3.13 **"Corner of bumper"** means the vehicle's point of contact with a vertical plane which makes an angle of 60° with the vertical longitudinal plane of the car and is tangential to the outer surface of the bumper (see Figure 5).

3.14 **"Femur"** of the lower legform impactor is defined as all components or parts of components (including flesh, skin covering, damper, instrumentation and brackets, pulleys, etc. attached to the impactor for the purpose of launching it) above the level of the centre of the knee.

3.15 **"Front reference line for child headform"** means the geometric trace as described on the vehicle front structure using a WAD1000 line. In the case of vehicles where the wrap around distance to the bonnet leading edge reference line, is more than 1,000 mm at any point, then the bonnet leading edge reference line will be used as the front reference line for child headform at that point.

3.16 **"Front structure"** means all outer structures of the vehicle except the windscreen, the windscreen header, the A-pillars and structures rearward of these. It therefore includes, but is not limited to, the bumper, the bonnet, wings, scuttle, wiper spindles and lower windscreen frame.

3.17 **"Ground reference plane"** means a horizontal plane, either real or imaginary, that passes through the lowest points of contact for all tyres of a vehicle while the vehicle is in its normal ride attitude. If the vehicle is resting on the ground, then the ground level and the ground reference plane are one and the same. If the vehicle is raised off the ground such as to allow extra clearance below the bumper, then the ground reference plane is above ground level.

3.18 **"Head Injury Criterion (HIC)"** means the calculated result of accelerometer time histories using the following formula:

$$\text{HIC} = \left[\frac{1}{t_2 - t_1} \int_{t_1}^{t_2} a \, dt \right]^{2.5} (t_2 - t_1)$$

Where:

a is the resultant acceleration measured in units of gravity "g" (1 g = 9.81 m/s^2);

t_1 and t_2 are the two time instants (expressed in seconds) during the impact, defining an interval between the beginning and the end of the recording period for which the value of HIC is a maximum ($t_2 - t_1 \leq 15$ ms)

3.19 **"Impact point"** means the point on the vehicle where initial contact by the test impactor occurs. The proximity of this point to the target point is dependent upon both the angle of travel by the test impactor and the contour of the vehicle surface (see point B in Figure 6).

3.20 **"Lower bumper height"** means the vertical distance between the ground reference plane and the lower bumper reference line, with the vehicle positioned in its normal ride attitude.

3.21 **"Lower bumper reference line"** means the lower limit to significant points of pedestrian contact with the bumper. It is defined as the geometric trace of the lowermost points of contact between a straight edge 700 mm long and the bumper, when the straight edge, held parallel to the vertical longitudinal plane of the car and inclined forwards by 25° from the vertical, is traversed across the front of the car, while maintaining contact with the ground and with the surface of the bumper (see Figure 7).

3.22 **"Normal ride attitude"** means the vehicle positioned on a flat horizontal surface with the following configuration :

- Mass of the vehicle with bodywork and all factory fitted equipment, electrical and auxiliary equipment for normal operation of vehicle, including liquids, tools, fire extinguisher, standard spare parts, chocks and spare wheel, if fitted.
- The fuel tank filled to at least 90 per cent of rated capacity and the other liquid containing systems (except those for used water) to 100 per cent of the capacity specified by the manufacturer.
- the tyres inflated to manufacturer recommended pressures,
- the front wheels in the straight-ahead position
- with driver & a passenger masses of 75kg positioned on the respective seats
- The front seats placed at the nominal mid-track position.
- The suspension set in normal running condition as specified by the manufacturer for a speed of 40 km/h.

3.23 **"Rear reference line for adult headform"** means a geometric trace as described on the front structure of the vehicle using a WAD2100 line.

3.24 **"Side reference line"** means the geometric trace of the highest points of contact between a straight edge 700 mm long and the sides of the vehicle, when the straight edge, held parallel to the transverse vertical plane of the vehicle and inclined inwards by 45°, is traversed down, and maintains contact with the sides of the front structure (see Figure 8).

3.25 **"Target point"** means the intersection of the projection of the headform longitudinal axis with the front surface of the vehicle (see point A in Figure 6).

3.26 **"Tibia"** of the lower legform impactor is defined as all components or parts of components (including flesh, skin covering, instrumentation and brackets, pulleys, etc. attached to the impactor for the purpose of launching it) below the level of the centre of the knee. Note that the tibia as defined includes allowances for the mass, etc., of the foot.

3.27 **"Upper bumper reference line"** means the upper limit to significant points of pedestrian contact with the bumper. For vehicles with an identifiable bumper structure it is defined as the geometric trace of the uppermost points of contact between a straight edge and the bumper, when the straight edge, held parallel to the vertical longitudinal plane of the car and inclined rearwards by 20° to the vertical, is traversed across the front of the car, while maintaining contact with the surface of the bumper (see Figure 9).

For vehicles with no identifiable bumper structure it is defined as the geometric trace of the uppermost points of contact between a straight edge 700 mm long and the bumper area, when the straight edge, held parallel to the vertical longitudinal plane of the car and inclined rearwards by 20° from the vertical is traversed across the front of the car, while maintaining contact with the ground and with the surface of the bumper area (see Figure 9).

3.28 **"Wrap Around Distance (WAD)"** means the geometric trace described on the outer surface of the vehicle front structure by one end of a flexible tape, when it is held in a vertical longitudinal plane of the vehicle and traversed across the front structure. The tape is held taut throughout the operation with one end held at the same level as the ground reference level, vertically below the front face of the bumper and the other end held in contact with the front structure (see Figure 10). The vehicle is positioned in the normal ride attitude.

This procedure shall be followed, using alternative tapes of appropriate lengths, to describe wrap around distances of 1,000 mm (WAD1000), of 1,700 mm (WAD1700) and of 2,100 mm (WAD2100).

3.29 **"Windscreen"** means the frontal glazing of the vehicle situated between the A-pillars.

3.30 **'Vehicle type'** means a category of vehicles which, forward of the A-pillars, do not differ in such essential respects as:

the structure,

the main dimensions,

the materials of the outer surfaces of the vehicle,

the component arrangement (external or internal),

insofar as they may be considered to have a negative effect on the results of the impact tests prescribed in this standard;

3.31 **'Vehicles of category N1 derived from M1'** means those vehicles of N1 category, forward of the A-pillar, have the same general structure and shape as a pre-existing M1 category vehicle.

3.32 **"R point"** or **"Seating reference point"** means a design point defined by the vehicle manufacturer for each seating position & established with respect to the three dimensional reference system.

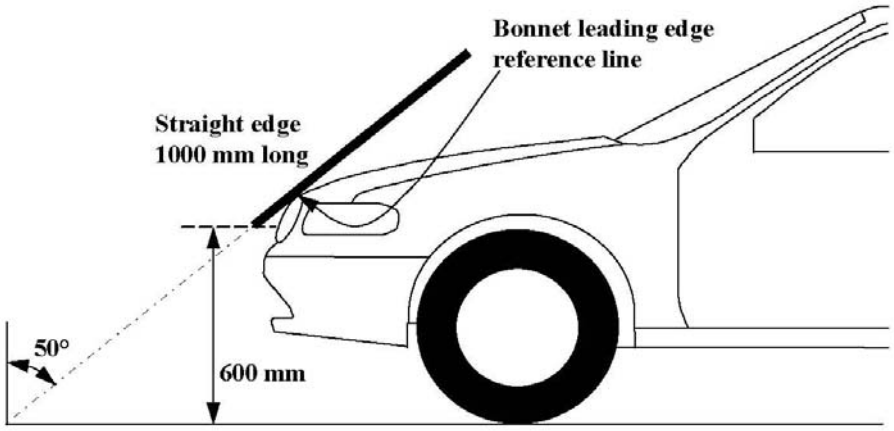


Figure 1

Bonnet Leading Edge Reference Line

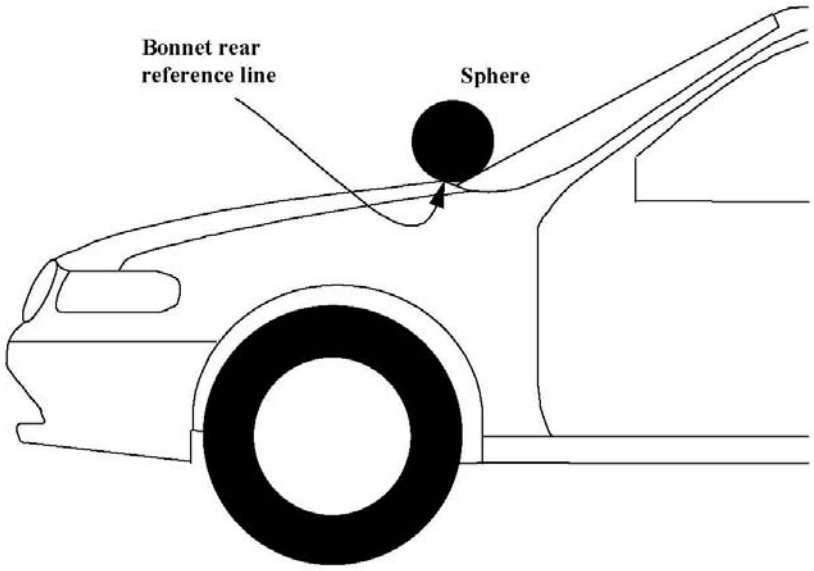


Figure 2

Bonnet Rear Reference Line

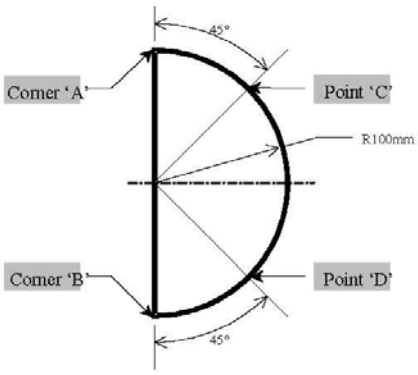


Figure 3

Template

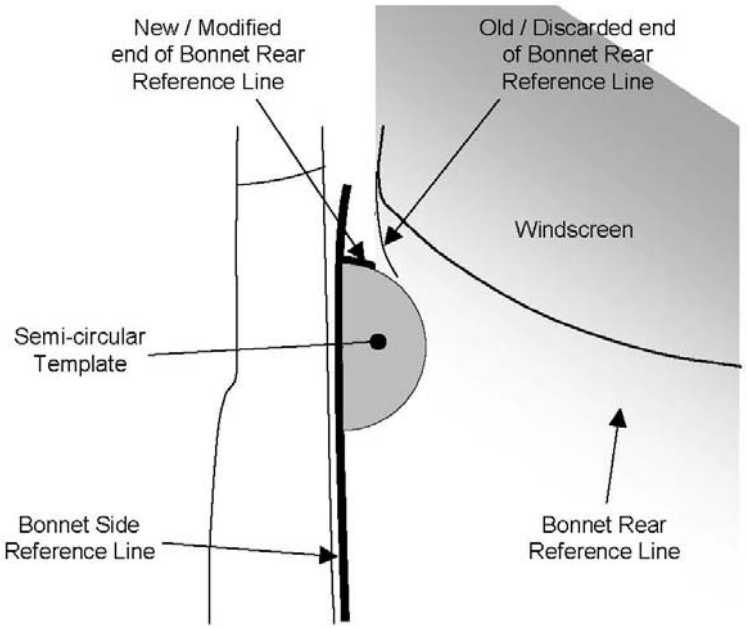


Figure 4

Marking of Intersection between Bonnet Rear and Side Reference Lines

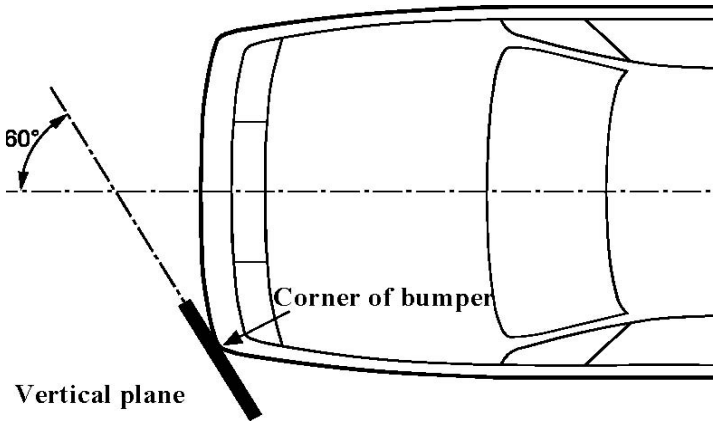


Figure 5

Corner of Bumper

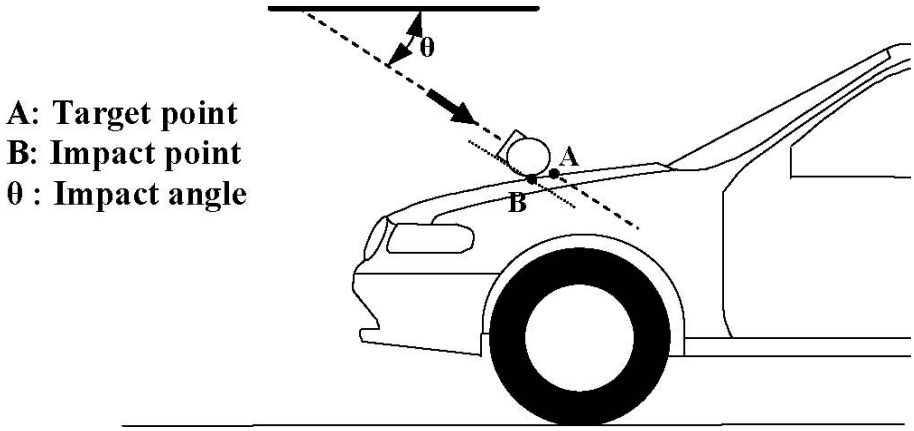


Figure 6

Impact and Target Point

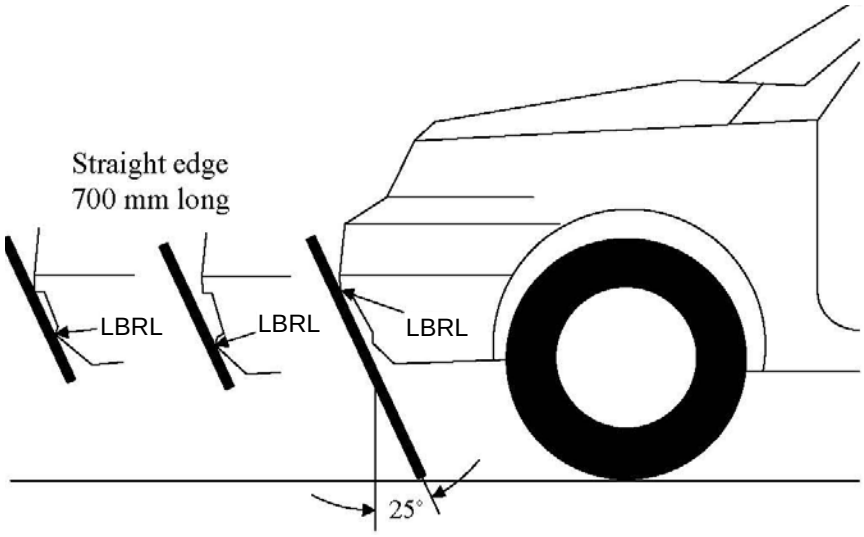


Figure 7

Lower Bumper Reference Line

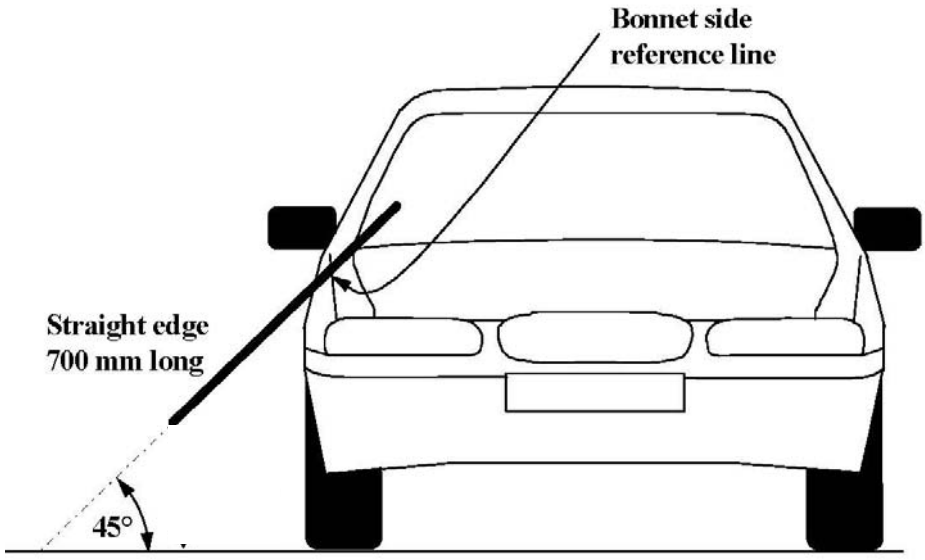


Figure 8

Side Reference Line

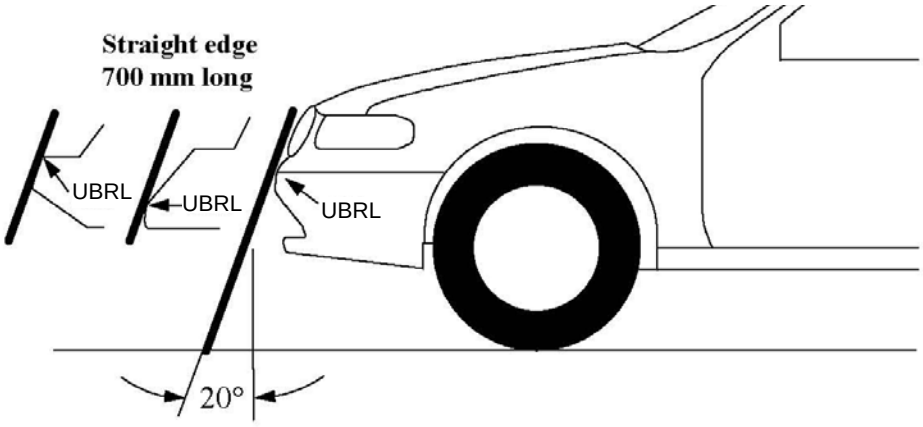


Figure 9

Upper Bumper Reference Line

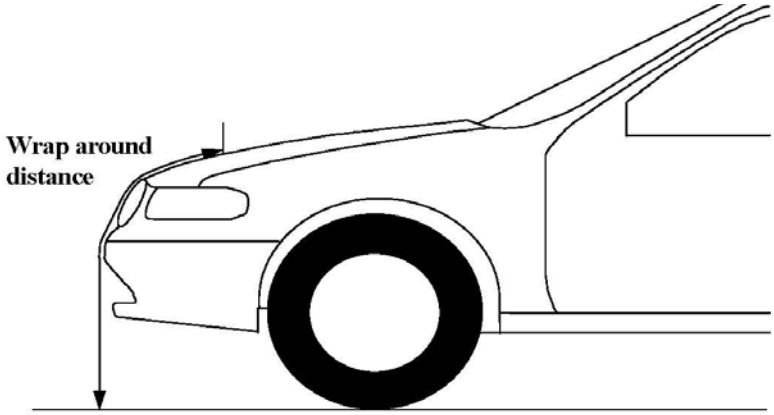


Figure 10

Wrap around Distance Measurement

4. GENERAL REQUIREMENTS.

4.1 **Legform test to bumper :**

For vehicles with a lower bumper height of less than 425 mm the requirements of paragraph 4.1.1 shall be applied.

For vehicles with a lower bumper height which is greater than, or equal to 425 mm and less than 500 mm the requirements of either paragraph 4.1.1 or 4.1.2, at the choice of the manufacturer, shall be applied.

For vehicles with a lower bumper height of greater than, or equal to, 500 mm the requirements of paragraph 4.1.2 shall be applied.

4.1.1 Lower legform to bumper:

To verify compliance with the performance requirements as specified in paragraph 5.1.1, both the test impactor specified in paragraph 6.3.1.1 and the test procedures specified in paragraph 7.1.1 shall be used.

4.1.2. Upper legform to bumper:

To verify compliance with the performance requirements as specified in paragraph 5.1.2, both the test impactor specified in paragraph 6.3.1.2 and the test procedures specified in paragraph 7.1.2 shall be used.

4.2. **Child headform impact:**

To verify compliance with the performance requirements as specified in paragraph 5.2.1, both the test impactor specified in paragraph 6.3.2.1 and the test procedures specified in paragraphs 7.2 and 7.3 shall be used.

4.3 **Adult headform impact**:

To verify compliance with the performance requirements as specified in paragraph 5.2.2, both the test impactor specified in paragraph 6.3.2.2 and the test procedures specified in paragraphs 7.2. and 7.4. shall be used.

5. PERFORMANCE REQUIREMENTS

5.1 **Legform to bumper:**

5.1.1 When tested in accordance with 7.1.1, the maximum dynamic knee bending angle shall not exceed 19°, the maximum dynamic knee shearing displacement shall not exceed 6.0 mm, and the acceleration measured at the upper end of the tibia shall not exceed 170 g. However, the manufacturer may nominate bumper test areas of widths total up to 264 mm where the acceleration measured at the upper end of the tibia may exceed up to 250g.

5.1.2 When tested in accordance with 7.1.2, the instantaneous sum of the impact forces with respect to time shall not exceed 7.5 kN and the bending moment on the test impactor shall not exceed 510 Nm.

5.2 **Headform tests**

5.2.1 Child headform to front structure:

When tested in accordance with 7.2 & 7.3, the HIC shall comply with paragraph 5.2.3.

5.2.2 Adult headform to the front structure:

When tested in accordance with 7.2 & 7.4, the HIC shall comply with paragraph 5.2.3.

5.2.3 The HIC recorded shall not exceed 1,000 over a minimum of one half of the child headform test area and 1,000 over two third of the combined child and adult headform test areas. The HIC for the remaining areas shall not exceed 1,700 for both headforms.

In case there is only a child headform test area, the HIC recorded shall not exceed 1,000 over two third of the test area. For the remaining area the HIC shall not exceed 1,700.

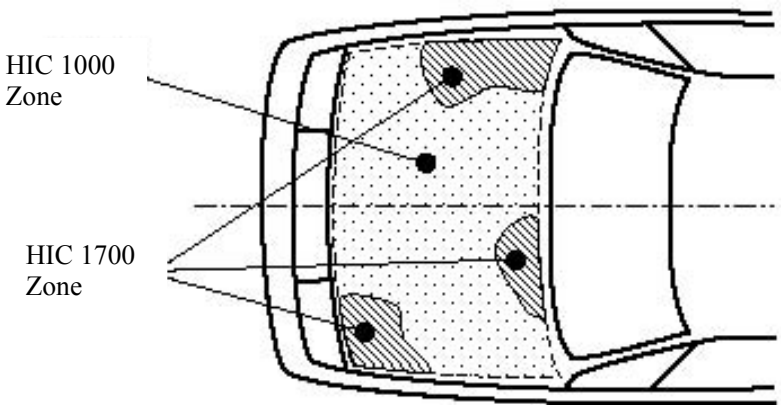


Figure 11

Example of Marking of HIC 1000 Zone & HIC 1700 Zone

5.2.4 Splitting of headform test zone

5.2.4.1 The manufacturer shall identify the zones of the bonnet top where the HIC must not exceed 1,000 (HIC1000 Zone) & 1,700 (HIC1700 Zone) respectively (see Figure 11).

5.2.4.2 Marking of the "bonnet top" impact area as well as "HIC1000 Zone" and "HIC1700 Zone" will be based on a drawing supplied by the manufacturer, when viewed from a horizontal plane above the vehicle that is parallel to the vehicle horizontal zero plane. A sufficient number of x and y co-ordinates shall be supplied by the manufacturer to mark up the areas on the actual vehicle while considering the vehicle outer contour in the z direction.

5.2.4.3 The areas of "HIC1000 Zone" and "HIC1700 Zone" may consist of several parts, with the number of these parts not being limited.

5.2.4.4 The calculation of the surface of the impact area as well as the surface areas of "HIC1000 Zone" and "HIC1700 Zone" shall be done on the basis of a projected bonnet when viewed from a horizontal plane parallel to the horizontal zero plane above the vehicle, on the basis of the drawing data supplied by the manufacturer.

6. TEST SPECIFICATIONS

6.1 General test conditions

6.1.1 Temperature and humidity

At the time of testing, the test facility and the vehicle or sub-system shall have a relative humidity of 40 per cent ± 30 per cent and stabilized temperature of 20 ± 4 °C.

6.1.2 Impact test site

The test site shall consist of a flat, smooth and hard surface with a slope not exceeding 1 per cent.

6.2 Preparation of the vehicle

6.2.1 Either a complete vehicle, or a cut-body, adjusted to the following conditions shall be used for the test.

6.2.1.1 The vehicle shall be in its normal ride attitude, and shall be either securely mounted on raised supports or at rest on a flat horizontal surface with the parking brake applied.

6.2.1.2 The cut-body shall include, in the test, all parts of the vehicle front structure, all under-bonnet components and all components behind the windscreen that may be involved in a frontal impact with a vulnerable road user, to demonstrate the performance and interactions of all the contributory vehicle components. The cut-body shall be securely mounted in the normal vehicle ride attitude.

6.2.2 All devices designed to protect vulnerable road users when impacted by the vehicle shall be correctly activated before and/or be active during the relevant test. It shall be the responsibility of the manufacturer to show that any devices will act as intended in a pedestrian impact.

6.2.3 For vehicle components which could change shape or position, other than active devices to protect pedestrians, and which have more than one fixed shape or position shall require the vehicle to comply with the components in each fixed shape or position.

6.3 **Test impactor specifications**

6.3.1 Legform impactors

6.3.1.1 Lower legform impactor

The lower legform impactor shall consist of two foam covered rigid segments, representing femur (upper leg) and tibia (lower leg), joined by a deformable, simulated knee joint. The overall length of the impactor shall be 926 ± 5 mm, having a required test mass of 13.4 ± 0.2 kg (see Figure 12). Dimensions of the various parts are detailed in Figure 12.

Brackets, pulleys, etc. attached to the impactor for the purpose of launching it, may extend the dimensions shown in Figure 12.

6.3.1.1.1 The diameter of the femur and tibia shall be 70 ± 1 mm and both shall be covered by foam ‘flesh' and skin. The foam flesh shall be 25 mm thick foam type CF-45 or equivalent. The skin shall be made of neoprene foam, faced with 0.5 mm thick nylon cloth both sides, with an overall thickness of 6 mm.

6.3.1.1.2 The knee joint shall be fitted with deformable knee elements from the same batch as those used in the certification tests.

6.3.1.1.3 The total masses of the femur and tibia shall be 8.6 ± 0.1 kg and 4.8 ± 0. 1 kg respectively, and the total mass of the impactor shall be 13.4 ± 0. 2 kg. The centre of gravity of the femur and tibia shall be 217 ± 10 mm and 233 ± 10 mm from the centre of the knee respectively. The moment of inertia of the femur and tibia, about a horizontal axis through the respective centre of gravity and perpendicular to the direction of impact, shall be 0.127 ± 0.010 kgm² and 0.120 ± 0.010 kgm² respectively.

6.3.1.1.4 For each test the impactor shall be fitted with new foam flesh cut from one of up to four consecutive sheets of foam flesh material or equivalent produced from the same batch of manufacture (cut from one block or ‘bun’ of foam), provided that foam from one of these sheets was used in the dynamic certification test and the individual weights of these sheets are within ± 2 % of the weight of the sheet used in the certification test.

6.3.1.1.5 The test impactor or at least the foam flesh shall be stored during a period of at least four hours in a controlled storage area with a stabilized humidity of 35 per cent ± 15 per cent and a stabilized temperature of 20 ± 4°C prior to impactor removal for calibration. After removal from the storage the impactor shall not be subjected to conditions other than those pertaining in the test area.

6.3.1.1.6 Lower legform instrumentation

6.3.1.1.6.1 A uniaxial accelerometer shall be mounted on the non-impacted side of the tibia, 66 ± 5 mm below the knee joint centre, with its sensitive axis in the direction of impact.

6.3.1.1.6.2 A damper shall be fitted to the shear displacement system and may be mounted at any point on the rear face of the impactor or internally. The damper properties shall be such that the impactor meets both the static and dynamic shear displacement requirements and prevents excessive vibrations of the shear displacement system.

6.3.1.1.6.3 Transducers shall be fitted to measure the bending angle and the shearing displacement between femur and tibia.

6.3.1.1.6.4 The instrumentation response value channel frequency class (CFC), as defined in ISO 6487:2002, shall be 180 for all transducers. The CAC response values, as defined in ISO 6487:2002, shall be 50° for the knee bending angle, 10 mm for the shearing displacement and 500 g for the acceleration. This does not require that the impactor itself be able to physically bend and shear to these angles and displacements.

6.3.1.1.7 Lower legform certification

6.3.1.1.7.1. The lower legform impactor shall meet the performance requirements specified in paragraph 8.

6.3.1.1.7.2. The certified impactor may be used for a maximum of 20 impacts before recertification. With each test new plastically deformable knee elements should be used. The impactor shall also be re-certified if more than one year has elapsed since the previous certification, if any impactor transducer output, in any impact, has exceeded the specified CAC or has reached the mechanical limits of the leg impactor deformation capability.

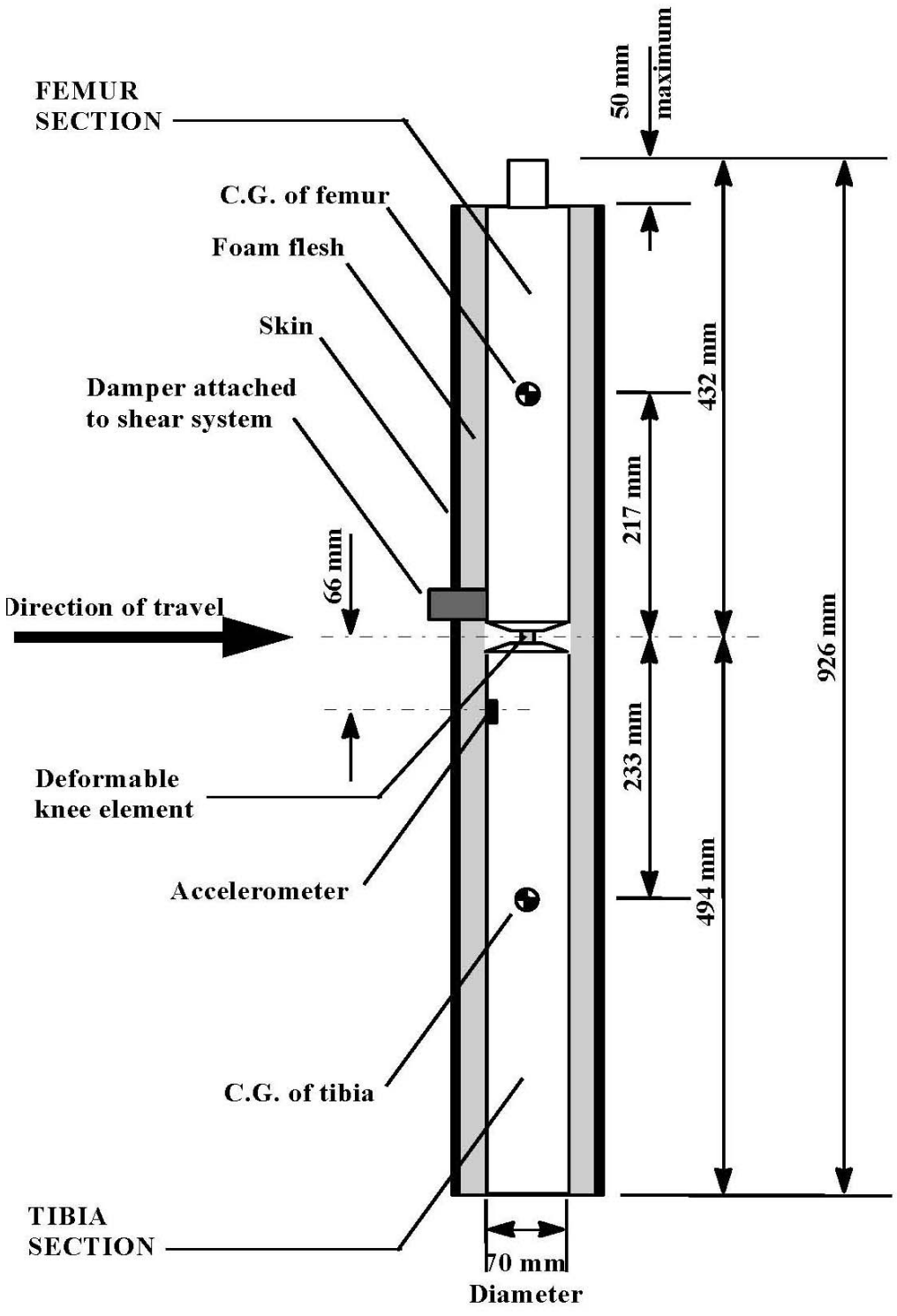


Figure 12

Lower Legform Impactor

6.3.1.2 Upper legform impactor :

The upper legform impactor shall be rigid, foam covered at the impact side, and 350 ± 5 mm long (see Figure 13).

6.3.1.2.1 The total mass of the upper legform impactor including those propulsion and guidance components which are effectively part of the impactor during the impact shall be 9.5 kg ± 0.1 kg.

6.3.1.2.2 The total mass of the front member and other components in front of the load transducer assemblies, together with those parts of the load transducer assemblies in front of the active elements, but excluding the foam and skin, shall be 1.95 ± 0.05 kg.

6.3.1.2.3 The upper legform impactor for the bumper test shall be mounted to the propulsion system by a torque-limiting joint and be insensitive to off-axis loading. The impactor shall move only in the specified direction of impact when in contact with the vehicle and shall be prevented from motion in other directions including rotation about any axis.

6.3.1.2.4 The torque limiting joint shall be set so that the longitudinal axis of the front member is vertical at the time of impact with a tolerance of ± 2°, with the joint friction torque set to 675 Nm ± 25 Nm.

6.3.1.2.5 The centre of gravity of those parts of the impactor which are effectively forward of the torque limiting joint, including extra masses fitted, shall lie on the longitudinal centre line of the impactor, with a tolerance of ± 10 mm.

6.3.1.2.6 The length between the load transducer centre lines shall be 310 ± 1 mm and the front member diameter shall be 50 ± 1 mm.

6.3.1.2.7 For each test the foam flesh shall be two new sheets of 25 mm thick foam type CF-45 or equivalent, which shall be cut from the sheet of material used for the dynamic certification test. The skin shall be a 1.5 mm thick fibre reinforced rubber sheet. The mass of the foam and rubber skin together shall weigh 0.6 ± 0.1 kg (this excludes any reinforcement, mountings, etc. which are used to attach the rear edges of the rubber skin to the rear member). The foam and rubber skin shall be folded back towards the rear, with the rubber skin attached via spacers to the rear member so that the sides of the rubber skin are held parallel. The foam shall be of such a size and shape that an adequate gap is maintained between the foam and components behind the front member, to avoid significant load paths between the foam and these components.

6.3.1.2.8 The test impactor or at least the foam flesh shall be stored during a period of at least four hours in a controlled storage area with a stabilized humidity of 35 per cent ± 15 per cent and a stabilized temperature of 20 ± 4°C prior to impactor removal for calibration. After removal from the storage the impactor shall not be subjected to conditions other than those pertaining in the test area.

6.3.1.2.9 Upper legform instrumentation

6.3.1.2.9.1 The front member shall be strain gauged to measure bending moments in three positions, as shown in Figure 13, each using a separate channel. The strain gauges are located on the impactor on the back of the front member. The two outer strain gauges are located 50 ± 1 mm from the impactor's symmetrical axis. The middle strain gauge is located on the symmetrical axis with a ± 1 mm tolerance.

6.3.1.2.9.2 Two load transducers shall be fitted to measure individually the forces applied at either end of the upper legform impactor, plus strain gauges measuring bending moments at the centre of the upper legform impactor and at positions 50 mm either side of the centre line, (see Figure 13).

6.3.1.2.9.3 The instrumentation response value CFC, as defined in ISO 6487:2002, shall be 180 for all transducers. The CAC response values, as defined in ISO 6487:2002, shall be 10 kN for the force transducers and 1000 Nm for the bending moment measurements.

6.3.1.2.10 Upper legform certification

6.3.1.2.10.1 The upper legform impactor shall meet the performance requirements specified in paragraph 8.

6.3.1.2.10.2 The certified impactor may be used for a maximum of 20 impacts before recertification (this limit does not apply to propulsion or guidance components). The impactor shall also be re-certified if more than one year has elapsed since the previous certification or if any impactor transducer output, in any impact, has exceeded the specified CAC.

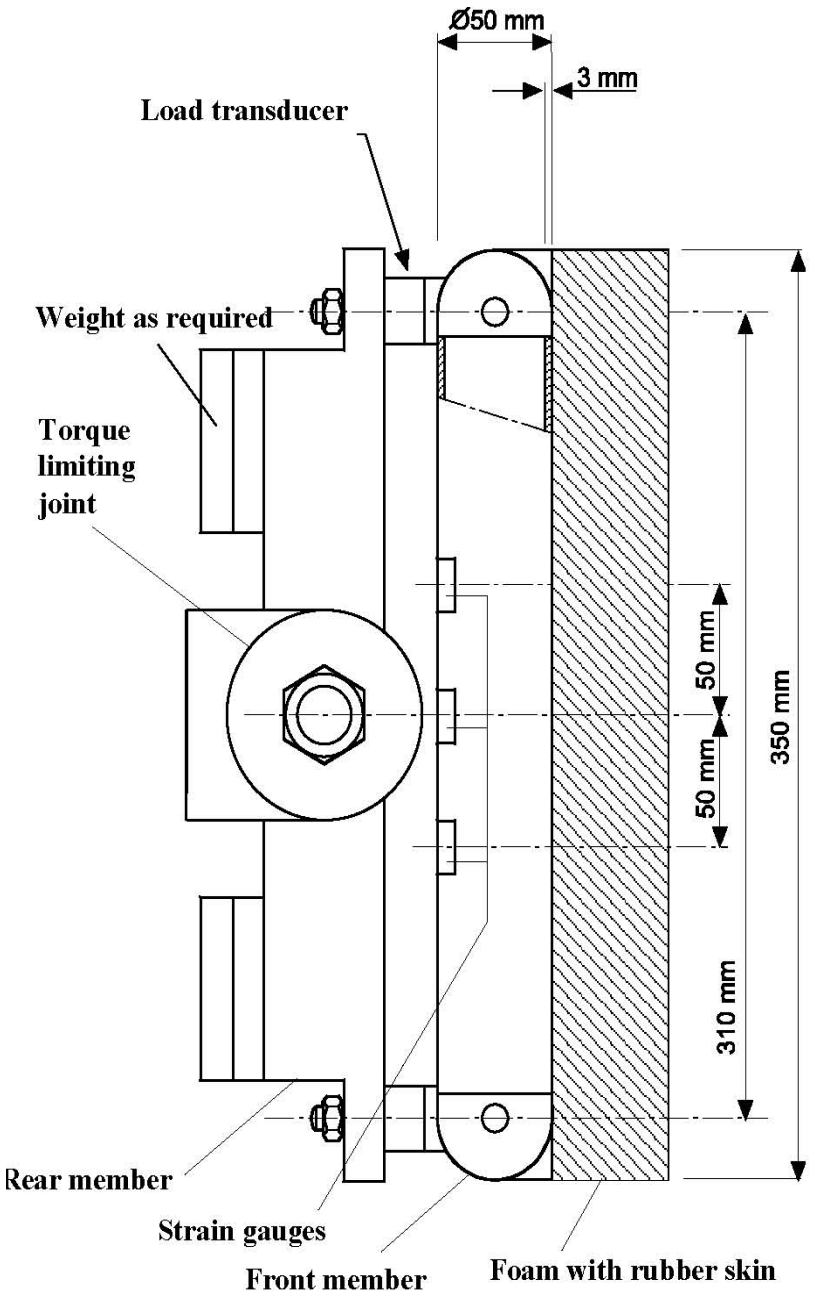


Figure 13

Upper Legform Impactor

6.3.2 Child & Adult headform impactors :

6.3.2.1 Child headform impactor (see Figure 14)

The child headform impactor shall be made of aluminium, be of homogenous construction and be of spherical shape. The overall diameter shall be 165 ± 1 mm. The mass shall be 3.5 ± 0.07 kg. The moment of inertia about an axis through the centre of gravity and perpendicular to the direction of impact shall be with in the range of 0.008 to 0.012 kgm^2. The centre of gravity of the headform impactor including instrumentation shall be located in the geometric centre of the sphere with a tolerance of ± 2 mm.

The sphere shall be covered with a 14 ± 0.5 mm thick synthetic skin, which shall cover at least half of the sphere.

6.3.2.1.1 Child headform instrumentation

A recess in the sphere shall allow for mounting one triaxial or three uniaxial accelerometers within ± 10 mm seismic mass location tolerance from the centre of the sphere for the measurement axis, and ± 1 mm seismic mass location tolerance from the centre of the sphere for the perpendicular direction to the measurement axis.

If three uniaxial accelerometers are used, one of the accelerometers shall have its sensitive axis perpendicular to the mounting face A (see Figure 14) and its seismic mass shall be positioned within a cylindrical tolerance field of 1 mm radius and 20 mm length. The centre line of the tolerance field shall run perpendicular to the mounting face and its mid-point shall coincide with the centre of the sphere of the headform impactor.

The remaining accelerometers shall have their sensitive axes perpendicular to each other and parallel to the mounting face A and their seismic mass shall be positioned within a spherical tolerance field of 10 mm radius. The centre of the tolerance field shall coincide with the centre of the sphere of the headform impactor.

The instrumentation response value CFC, as defined in ISO 6487: 2002, shall be 1,000. The CAC response value, as defined in ISO 6487: 2002, shall be 500 g for the acceleration.

6.3.2.1.2 First natural frequency

The first natural frequency of the headform impactor shall be over 5,000 Hz.

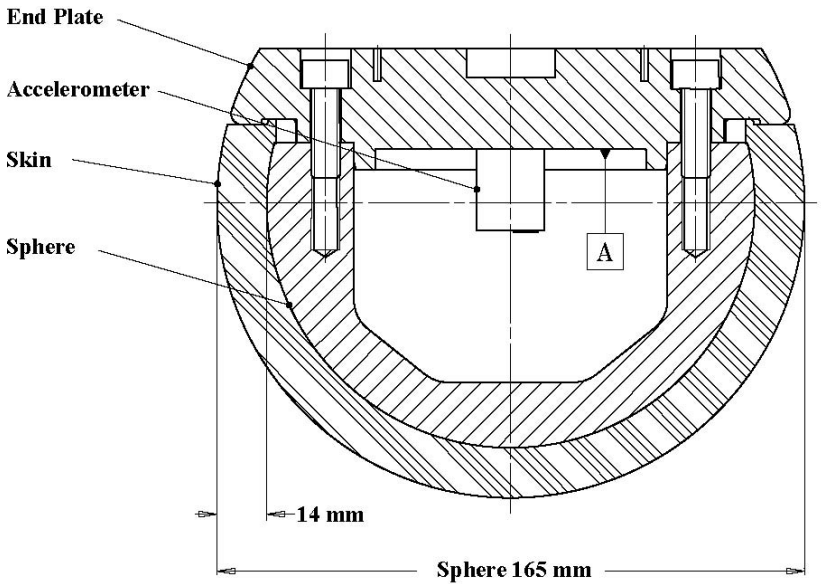


Figure 14

Child Headform Impactor

6.3.2.2 Adult headform impactor (see Figure 15)

The adult headform impactor shall be made of aluminium, be of homogenous construction and be of spherical shape. The overall diameter is 165 ± 1 mm as shown in Figure 15. The mass shall be 4.5 ± 0.1 kg. The moment of inertia about an axis through the centre of gravity and perpendicular to the direction of impact shall be with in the range of 0.010 to 0.013 kgm^2. The centre of gravity of the headform impactor including instrumentation shall be located in the geometric centre of the sphere with a tolerance of ± 5 mm.

The sphere shall be covered with a 14 ± 0.5 mm thick synthetic skin, which shall cover at least half of the sphere.

6.3.2.2.1 Adult headform instrumentation

A recess in the sphere shall allow for mounting one triaxial or three uniaxial accelerometers within ± 10 mm seismic mass location tolerance from the centre of the sphere for the measurement axis, and ± 1 mm seismic mass location tolerance from the centre of the sphere for the perpendicular direction to the measurement axis.

If three uniaxial accelerometers are used, one of the accelerometers shall have its sensitive axis perpendicular to the mounting face A (see Figure 15) and its seismic mass shall be positioned within a cylindrical tolerance field of 1 mm radius and 20 mm length.

The centre line of the tolerance field shall run perpendicular to the mounting face and its mid-point shall coincide with the centre of the sphere of the headform impactor.

The remaining accelerometers shall have their sensitive axes perpendicular to each other and parallel to the mounting face A and their seismic mass shall be positioned within a spherical tolerance field of 10 mm radius. The centre of the tolerance field shall coincide with the centre of the sphere of the headform impactor.

The instrumentation response value CFC, as defined in ISO 6487: 2002, shall be 1,000. The CAC response value, as defined in ISO 6487: 2002, shall be 500 g for the acceleration.

6.3.2.2.2 First natural frequency.

The first natural frequency of the headform impactor shall be over 5,000 Hz.

6.3.2.3 Rear face of the headform impactors

A rear flat face shall be provided on the outer surface of the headform impactors which is perpendicular to the direction of travel, and typically perpendicular to the axis of one of the accelerometers as well as being a flat plate capable of providing for access to the accelerometers and an attachment point for the propulsion system.

6.3.2.4 Certification of the headform impactors

The headform impactors shall meet the performance requirements specified in paragraph 8. The certified impactors may be used for a maximum of 20 impacts before re-certification. The impactors shall be re-certified if more than one year has elapsed since the previous certification or if the transducer output, in any impact, has exceeded the specified CAC.

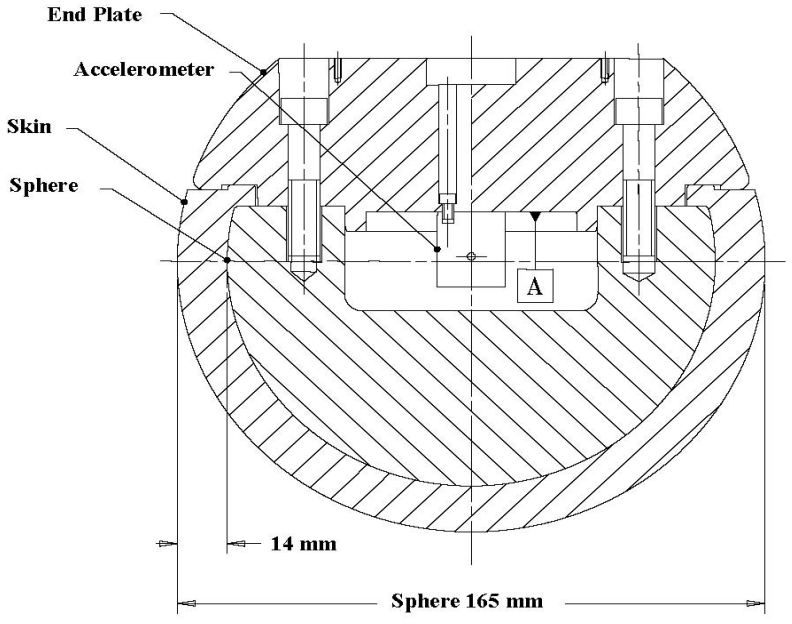


Figure 15

Adult Headform Impactor

7. TEST PROCEDURES

7.1 Legform to bumper test procedures :

7.1.1 Lower legform to bumper test procedure:

Each test shall be completed within two hours of when the impactor to be used is removed from the controlled storage area.

7.1.1.1 The selected target points shall be in the bumper test area.

7.1.1.2 The direction of the impact velocity vector shall be in the horizontal plane and parallel to the longitudinal vertical plane of the vehicle. The tolerance for the direction of the velocity vector in the horizontal plane and in the longitudinal plane shall be ± 2° at the time of first contact. The axis of the impactor shall be perpendicular to the horizontal plane with a tolerance of ± 2° in the lateral and longitudinal plane. The horizontal, longitudinal and lateral planes are orthogonal to each other (see Figure 16).

7.1.1.3 The bottom of the impactor shall be at 25 mm above ground reference plane at the time of first contact with the bumper (see Figure 17), with a ± 10 mm tolerance. When setting the height of the propulsion system, an allowance must be made for the influence of gravity during the period of free flight of the impactor.

7.1.1.3.1 The lower legform impactor for the bumper tests shall be in 'free flight' at the moment of impact. The impactor shall be released to free flight at such a distance from the vehicle that the test results are not influenced by contact of the impactor with the propulsion system during rebound of the impactor.

The impactor may be propelled by an air, spring or hydraulic gun, or by other means that can be shown to give the same result.

7.1.1.3.2 At the time of first contact the impactor shall have the intended orientation about its vertical axis, for the correct operation of its knee joint, with a tolerance of ± 5° (see Figure 16).

7.1.1.3.3 At the time of first contact the centre line of the impactor shall be within a ± 10 mm tolerance to the selected impact location.

7.1.1.3.4 During contact between the impactor and the vehicle, the impactor shall not contact the ground or any object which is not part of the vehicle.

7.1.1.4 The impact velocity of the impactor when striking the bumper shall be 11.1 ± 0.2 m/s. The effect of gravity shall be taken into account when the impact velocity is obtained from measurements taken before the time of first contact.

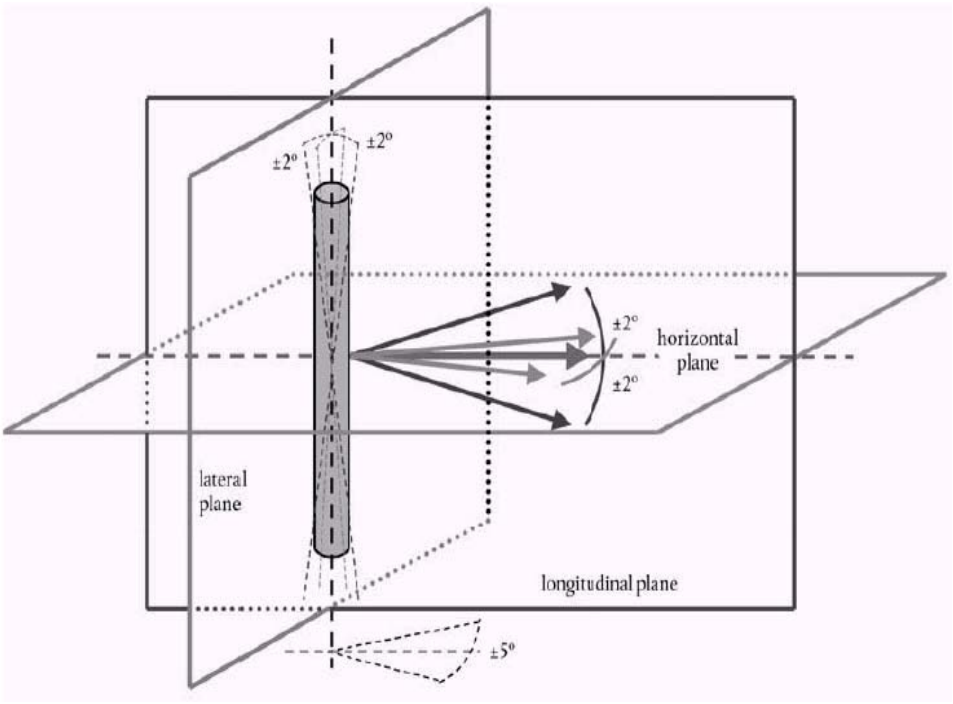


Figure 16

Tolerances of Angles for the Lower Legform Impactor at the time of the First Impact (see paragraphs 7.1.1.2 & 7.1.1.3.2)

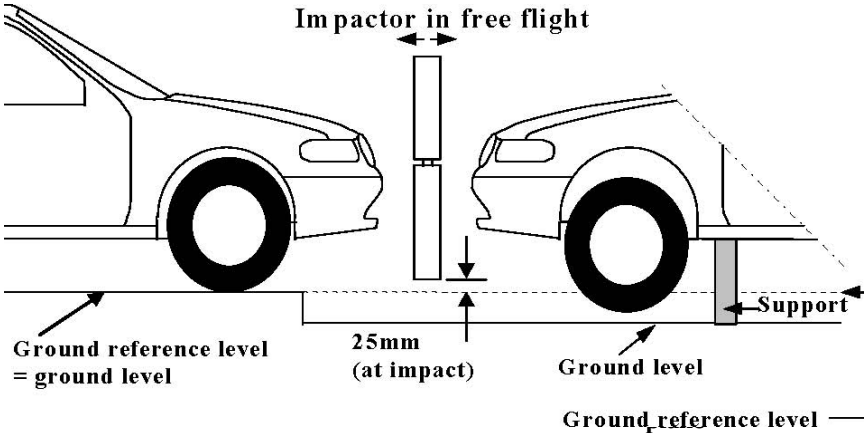


Figure 17

Lower Legform to Bumper Tests for Complete Vehicle in Normal Ride Attitude (Left) and for Cut-Body Mounted on Supports (Right)

7.1.2 Upper legform to bumper test procedure :

Each test shall be completed within two hours of when the impactor to be used is removed from the controlled storage area.

7.1.2.1 The selected target points shall be in the bumper test area as defined in paragraph 3.10.

7.1.2.2 The direction of impact shall be parallel to the longitudinal axis of the vehicle, with the axis of the upper legform vertical at the time of first contact. The tolerance to this direction is ± 2°.

At the time of first contact the impactor centre line shall be vertically midway between the upper bumper reference line and the lower bumper reference line with a ± 10 mm tolerance and the impactor vertical centre line shall be positioned laterally with the selected impact location with a tolerance of ± 10 mm.

7.1.2.3 The impact velocity of the upper legform impactor when striking the bumper shall be 11.1 ± 0.2 m/s.

7.2 **Headform test procedures**

7.2.1 Propulsion of the headform impactors

The headform impactors shall be in "free flight" at the moment of impact, at the required impact velocity (as specified in paragraphs 7.3.4. and 7.4.4.) and the required direction of impact (as specified in paragraphs 7.3.5. and 7.4.5.).

The impactors shall be released to "free flight" at such a distance from the vehicle that the test results are not influenced by contact of the impactor with the propulsion system during rebound of the impactor.

7.2.2 Measurement of impact velocity

The velocity of the headform impactor shall be measured at some point during the free flight before impact, in accordance with the method specified in ISO 3784:1976. The accuracy of velocity measurement shall be ± 0.01 m/sec. The measured velocity shall be adjusted considering all factors which may affect the impactor between the point of measurement and the point of impact, in order to determine the velocity of the impactor at the time of impact. The angle of the velocity vector at the time of impact shall be calculated or measured.

7.2.3 Recording

The acceleration time histories shall be recorded, and HIC shall be calculated. The first point of contact on the front structure of the vehicle shall be recorded. Recording of test results shall be in accordance with ISO 6487:2002.

7.3 **Child headform test procedure**

This test procedure is applicable with respect to the requirements of paragraphs 5.2.1. and 5.2.3.

7.3.1 Tests shall be made to the front structure within the boundaries as defined in paragraph 3.12. For tests on the rear area of the bonnet top, the headform impactor shall not contact the windscreen or A-pillar before impacting the bonnet top.

7.3.2 No impact point shall be located so that the impactor will impact the test area with a glancing blow resulting in a more severe second impact outside the test area.

Selected impact points on the bonnet for the child headform impactor shall be, at the time of first contact:

(a) a minimum of 82.5 mm inside the defined side reference lines, and;

(b) forward of the WAD1700 line, or, a minimum of 82.5 mm forwards of the bonnet rear reference line,

whichever is most forward at the point of measurement, and;

(c) be rearward of the WAD1000 line, or, a minimum of 82.5 mm rearwards of the bonnet leading edge reference line, whichever is most rearward at the point of measurement [1/].

These minimum distances are to be set with a flexible tape held tautly along the outer surface of the vehicle.

7.3.3 The point of first contact of the headform impactor shall be within a ± 10 mm tolerance to the selected impact point.

7.3.4 The headform velocity at the time of impact shall be 9.7 ± 0.2 m/s.

7.3.5 The direction of impact shall be in the longitudinal vertical plane of the vehicle to be tested at an angle of 50 ± 2° to the horizontal. The direction of impact of tests to the front structure shall be downward and rearward.

1/ Based on the European practice, the test agency may choose to maintain a minimum distance of 165mm between the impact points.

7.4 **Adult headform test procedure:**

This test procedure is applicable with respect to the requirements of paragraphs 5.2.2. and 5.2.3.

7.4.1 Tests shall be made to the front structure within the boundaries as defined in paragraph 3.1. For tests at the rear of the bonnet top, the headform impactor shall not contact the windscreen or A-pillar before impacting the bonnet top.

7.4.2 No impact point shall be located so that the impactor will impact the test area with a glancing blow resulting in a more severe second impact outside the test area.

Selected impact points on the bonnet for the adult headform impactor shall be, at the time of first contact:

(1) a minimum of 82.5 mm inside the defined side reference lines, and;

(2) forward of the WAD2100 line, or,

a minimum of 82.5 mm forward of the bonnet rear reference line, whichever is most forward at the point of measurement, and;

(3) rearward of the WAD1700 line.

These minimum distances are to be set with a flexible tape held tautly along the outer surface of the vehicle. 2/

7.4.3 The point of first contact of the headform impactor shall be within a ± 10 mm tolerance to the selected impact point.

7.4.4 The headform velocity at the time of impact shall be 9.7 ± 0.2 m/s.

7.4.5 The direction of impact shall be in the longitudinal vertical plane of the paragraph of the vehicle to be tested at an angle of 65° ± 2° to the horizontal. The direction of impact of tests to the front structure shall be downward and rearward.

2/ Based on the European practice, the test agency may choose to maintain a minimum distance of 165 mm between the impact points.

8. CERTIFICATION OF IMPACTORS

The impactors that are used in the tests described in this standard are required to comply with the following performance requirements.

The requirements for the lower legform impactor are specified in paragraph 8.1., the upper legform impactor requirements are specified in paragraph 8.2. and the adult and child headform impactors requirements are specified in paragraph 8.3

8.1 Lower legform impactor certification :

8.1.1 Static tests

8.1.1.1 Lower legform impactor shall meet the requirements specified in paragraph 8.1.1.2. when tested as specified in paragraph 8.1.1.4. and the requirements specified in paragraph 8.1.1.3. when tested as specified in paragraph 8.1.1.5.

For both tests the impactor shall have the intended orientation about its longitudinal axis, for the correct operation of its knee joint, with a tolerance of ± 2°.

The stabilised temperature of the impactor during certification shall be 20° ± 2° C.

The CAC response values, as defined in ISO 6487:2002, shall be 50° for the knee bending angle and 500 N for the applied force when the impactor is loaded in bending in accordance with paragraph 8.1.1.4, and 10 mm for the shearing displacement and 10 kN for the applied force when the impactor is loaded in shearing in accordance with paragraph 8.1.1.5. For both tests low-pass filtering at an appropriate frequency is permitted, to remove higher frequency noise without significantly affecting the measurement of the response of the impactor.

8.1.1.2 When the impactor is loaded in bending in accordance with paragraph 8.1.1.4, the applied force/bending angle response shall be within the limits shown in Figure 18. Also, the energy taken to generate 15.0° of bending shall be 100 ± 7 J.

8.1.1.3 When the impactor is loaded in shearing in accordance with paragraph 8.1.1.5, the applied force/shearing displacement response shall be within the limits shown in Figure 19.

8.1.1.4 The impactor, without foam covering and skin, shall be mounted with the tibia firmly clamped to a fixed horizontal surface and a metal tube connected firmly to the femur, as shown in Figure 20. The rotational axis of the impactor knee joint shall be vertical. To avoid friction errors, no support shall be provided to the femur section or the metal tube. The bending moment applied at the centre of the knee joint, due to the mass of the metal tube and other components (excluding the legform itself), shall not exceed 25 Nm.

A horizontal normal force shall be applied to the metal tube at a distance of 2.0 ± 0.01 m from the centre of the knee joint and the resulting angle of knee deflection shall be recorded. The load shall be increased at a rate between 1.0 & 10 ^{0}/s until the angle of deflection of the knee is in excess of 22°. Brief excursions from these limits due, for instance, to the use of a hand pump shall be permitted.

The energy is calculated by integrating the force with respect to the bending angle in radians, and multiplying by the lever length of 2.0 ± 0.01 m.

8.1.1.5 The impactor, without foam covering and skin, shall be mounted with the tibia firmly clamped to a fixed horizontal surface and a metal tube connected firmly to the femur and restrained at 2.0 m from the centre of the knee joint, as shown in Figure 21.

A horizontal normal force shall be applied to the femur at a distance of 50 mm from the centre of the knee joint and the resulting knee shearing displacement shall be recorded. The load shall be increased at a rate between 0.1 & 20 mm/s until the shearing displacement of the knee is in excess of 7.0 mm or the load is in excess of 6.0 kN. Brief excursions from these limits due, for instance, to the use of a hand pump shall be permitted.

8.1.2 Dynamic tests

8.1.2.1 The lower legform impactor shall meet the requirements specified in paragraph 8.1.2.3. when tested as specified in paragraph 8.1.2.4.

8.1.2.2 Calibration :

8.1.2.2.1 The foam flesh for the test impactor shall be stored for a period of at least four hours in a controlled storage area with a stabilized humidity of 35 ± 10 per cent and a stabilized temperature of 20 ± 2°C prior to impactor removal for calibration. The test impactor itself shall have a temperature of 20° ± 2°C at the time of impact. The temperature tolerances for the test impactor shall apply at a relative humidity of 40 ± 30 per cent after a soak period of at least four hours prior to their application in a test.

8.1.2.2.2 The test facility used for the calibration test shall have a stabilized humidity of 40 ± 30 per cent and a stabilized temperature of 20 ± 4°C during calibration.

8.1.2.2.3 Each calibration shall be completed within two hours of when the impactor to be calibrated is removed from the controlled storage area.

8.1.2.2.4 The relative humidity and temperature of the calibration area shall be measured at the time of calibration and recorded in the calibration report.

8.1.2.3 Requirements :

8.1.2.3.1 When the impactor is impacted by a linearly guided certification impactor, as specified in paragraph 8.1.2.4, the maximum upper tibia acceleration shall be not less than 120 g and not more than 250 g. The maximum bending angle shall be not less than 6.2° and not more than 8.2°. The maximum shearing displacement shall be not less than 3.5 mm and not more than 6.0 mm.

For all these values the readings used shall be from the initial impact with the certification impactor and not from the arresting phase. Any system used to arrest the impactor or certification impactor shall be so arranged that the arresting phase does not overlap in time with the initial impact. The arresting system shall not cause the transducer outputs to exceed the specified CAC.

8.1.2.3.2 The instrumentation response value CFC, as defined in ISO 6487:2002, shall be 180 for all transducers. The CAC response values, as defined in ISO 6487:2002, shall be 50° for the knee bending angle, 10 mm for the shearing displacement and 500 g for the acceleration. This does not require that the impactor itself be able to physically bend and shear to these angles and displacements.

8.1.2.4 Test procedure

8.1.2.4.1 The impactor, including foam covering and skin, shall be suspended horizontally by three wire ropes of 1.5 ± 0.2 mm diameter and of 2.0 m minimum length, as shown in Figure 22. It shall be suspended with its longitudinal axis horizontal, with a tolerance of ± 0.5°, and perpendicular to the direction of the certification impactor motion, with a tolerance of ± 2°. The impactor shall have the intended orientation about its longitudinal axis, for the correct operation of its knee joint, with a tolerance of ± 2°. The impactor must meet the requirements of paragraph 6.3.1.1, with the attachment bracket(s) for the wire ropes fitted.

8.1.2.4.2 The certification impactor shall have a mass of 9.0 ± 0.05 kg, this mass includes those propulsion and guidance components which are effectively part of the impactor during impact. The dimensions of the face of the certification impactor shall be as specified in Figure 23. The face of the certification impactor shall be made of aluminium, with an outer surface finish of better than 2.0 micrometers.

The guidance system shall be fitted with low friction guides, insensitive to off-axis loading, that allow the impactor to move only in the specified direction of impact, when in contact with the vehicle. The guides shall prevent motion in other directions including rotation about any axis.

8.1.2.4.3 The impactor shall be certified with previously unused foam.

8.1.2.4.4 The impactor foam shall not be excessively handled or deformed before, during or after fitting.

8.1.2.4.5 The certification impactor shall be propelled horizontally at a velocity of 7.5 ± 0.1 m/s into the stationary impactor as shown in Figure 22 (GTR fig 23). The certification impactor shall be positioned so that its centreline aligns with a position on the tibia centreline of 50 mm from the centre of the knee, with tolerances of ± 3 mm laterally and ± 3 mm vertically.

8.2 **Upper legform impactor certification :**

8.2.1 The upper legform impactor shall meet the requirements specified in paragraph 8.2.3 when tested as specified in paragraph 8.2.4.

8.2.2 Calibration

8.2.2.1 The foam flesh for the test impactor shall be stored for a period of at least four hours in a controlled storage area with a stabilized humidity of 35 ± 10 per cent and a stabilized temperature of 20° ± 2°C prior to impactor removal for calibration. The test impactor itself shall have a temperature of 20° ± 2°C at the time of impact. The temperature tolerances for the test impactor shall apply at a relative humidity of 40 ± 30 per cent after a soak period of at least four hours prior to their application in a test.

8.2.2.2 The test facility used for the calibration test shall have a stabilized humidity of 40 ± 30 per cent and a stabilized temperature of 20° ± 4°C during calibration.

8.2.2.3 Each calibration shall be completed within two hours of when the impactor to be calibrated is removed from the controlled storage area.

8.2.2.4 The relative humidity and temperature of the calibration area shall be measured at the time of calibration, and recorded in a calibration report.

8.2.3 Requirements

8.2.3.1 When the impactor is propelled into a stationary cylindrical pendulum the peak force measured in each load transducer shall be not less 1.20 kN and not more than 1.55 kN and the difference between the peak forces measured in the top and bottom load transducers shall not be more than 0.10 kN. Also, the peak bending moment measured by the strain gauges shall not be less than 190 Nm and not more than 250 Nm on the centre position and not less than 160 Nm and not more than 220 Nm for the outer positions. The difference between the upper and lower peak bending moments shall not be more than 20 Nm.

For all these values the readings used shall be from the initial impact with the pendulum and not from the arresting phase. Any system used to arrest the impactor or pendulum shall be so arranged that the arresting phase does not overlap in time with the initial impact. The arresting system shall not cause the transducer outputs to exceed the specified CAC.

8.2.3.2 The instrumentation response value CFC, as defined in ISO 6487:2002, shall be 180 for all transducers. The CAC response values, as defined in ISO 6487:2002, shall be 10 kN for the force transducers and 1000 Nm for the bending moment measurements.

8.2.4 Test procedure

8.2.4.1 The impactor shall be mounted to the propulsion and guidance system, by a torque limiting joint. The torque limiting joint shall be set so that the longitudinal axis of the front member is perpendicular to the axis of the guidance system, with a tolerance of ± 2°, with the joint friction torque set to 675 ± 25 Nm. The guidance system shall be fitted with low friction guides that allow the impactor to move only in the specified direction of impact, when in contact with the pendulum.

8.2.4.2 The impactor mass shall be adjusted to give a mass of 12 ± 0.1 kg, this mass includes those propulsion and guidance components which are effectively part of the impactor during impact.

8.2.4.3 The centre of gravity of those parts of the impactor which are effectively forward of the torque limiting joint, including the extra weights fitted, shall lie on the longitudinal centreline of the impactor, with a tolerance of ± 10 mm.

8.2.4.4 The impactor shall be certified with previously unused foam.

8.2.4.5 The impactor foam shall not be excessively handled or deformed before, during or after fitting.

8.2.4.6 The impactor with the front member vertical shall be propelled horizontally at a velocity of 7.1 ± 0.1 m/s into the stationary pendulum as shown in Figure 24.

8.2.4.7 The pendulum tube shall have a mass of 3 ± 0.03 kg, a wall thickness of 3 ± 0.15 mm and an outside diameter of 150 mm +1mm /- 4 mm. Total pendulum tube length shall be 275 ± 25 mm. The pendulum tube shall be made from cold finished seamless steel (metal surface plating is permissible for protection from corrosion), with an outer surface finish of better than 2.0 micrometer. It shall be suspended on two wire ropes of 1.5 ± 0.2 mm diameter and of 2.0 m minimum length. The surface of the pendulum shall be clean and dry. The pendulum tube shall be positioned so that the longitudinal axis of the cylinder is perpendicular to the front member (i.e. level), with a tolerance of ± 2°, and to the direction of impactor motion, with a tolerance of ± 2°, and with the centre of the pendulum tube aligned with the centre of the impactor front member, with tolerances of ± 5 mm laterally and ± 5 mm vertically.

8.3 **Child and adult headform impactors certification**

8.3.1 Drop test

8.3.1.1 Performance Criteria

The headform impactors shall meet the requirements specified in paragraph 8.3.2. when tested as specified in paragraph 8.3.3.

8.3.2 Requirements

8.3.2.1 When the headform impactors are dropped from a height of 376 ± 1 mm in accordance with paragraph 8.3.3. the peak resultant acceleration measured by one triaxial (or three uniaxial) accelerometer (accelerometers) in the headform impactor shall be:

(a) for the child headform impactor not less than 245 g and not more than 300 g;

(b) for the adult headform impactor not less than 225 g and not more than 275 g.

The acceleration time curve shall be uni-modal.

8.3.2.2 The instrumentation response values CFC and CAC for each accelerometer shall be 1000 Hz and 500 g respectively as defined in ISO 6487:2002.

8.3.2.3 Temperature conditions

The headform impactors shall have a temperature of 20 ± 2°C at the time of impact. The temperature tolerances shall apply at a relative humidity of 40 ± 30 per cent after a soak period of at least four hours prior to their application in a test.

8.3.2.4 After complying with the certification test, each headform impactor can be used for a maximum of 20 impact tests.

8.3.3 Test Procedure

8.3.3.1 The headform impactor shall be suspended from a drop rig as shown in Figure 25.

8.3.3.2 The headform impactor shall be dropped from the specified height by means that ensure instant release onto a rigidly supported flat horizontal steel plate, over 50 mm thick and over 300 X 300 mm square which has a clean dry surface and a surface finish of between 0.2 and 2.0 micrometers.

8.3.3.3 The headform impactor shall be dropped with the rear face of the impactor at the test angle specified in paragraph 7.3.5. for the child headform impactor and in paragraph 7.4.5. for the adult headform impactor with respect to the vertical as shown in Figure 25. The suspension of the headform impactor shall be such that it does not rotate during the fall.

8.3.3.4 The drop test shall be performed three times, with the headform impactor rotated 120° around its symmetrical axis after each test.

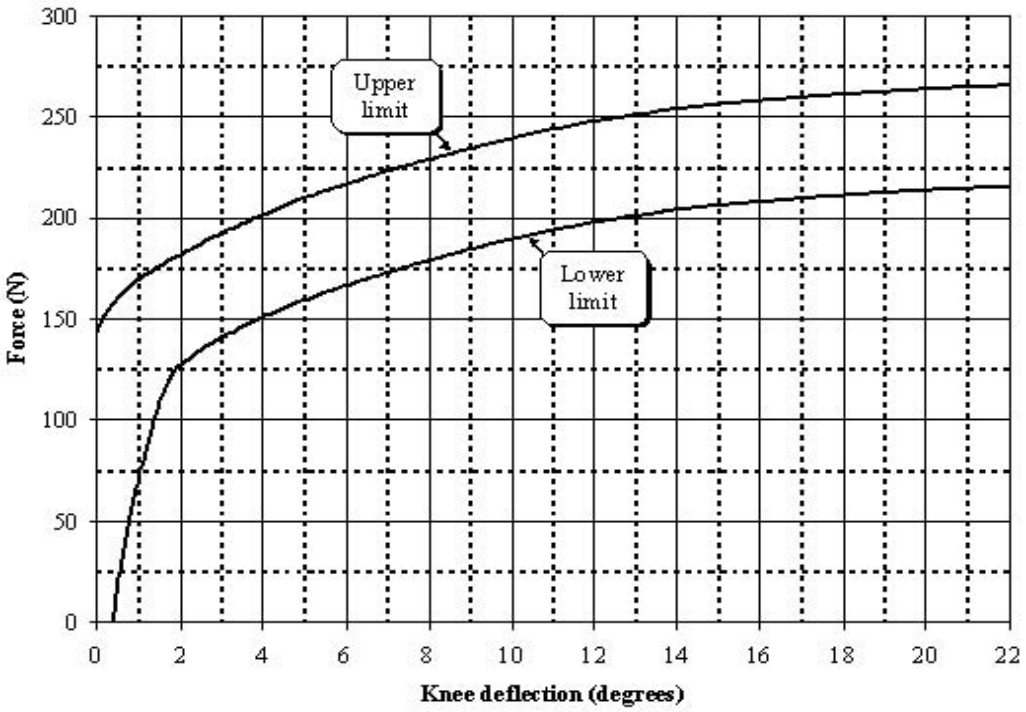


Figure 18

Force Versus Angle Requirements in Static Lower Legform Impactor Bending Certification Test

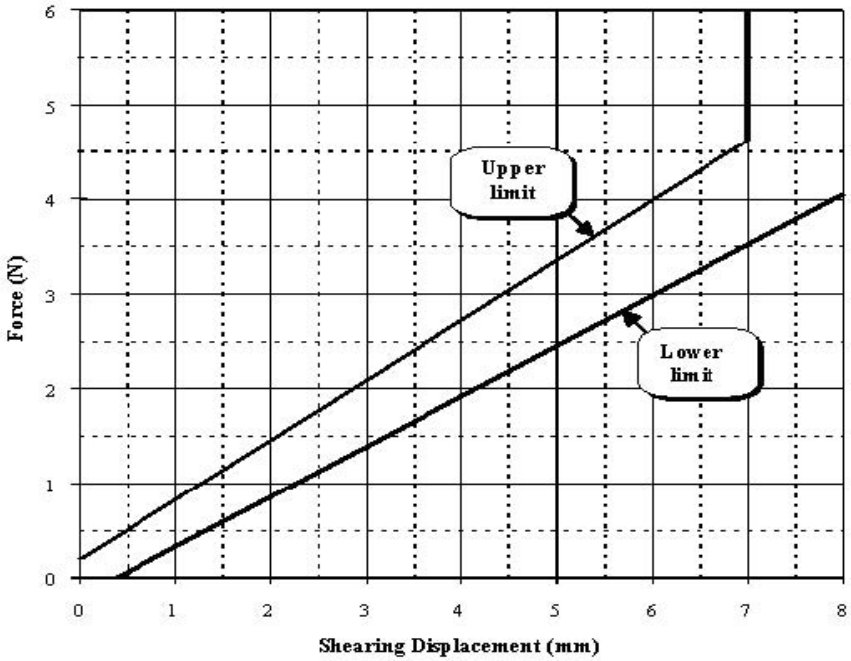


Figure 19

Force Versus Displacement Requirements in Static Lower Legform Impactor Shearing Certification Test

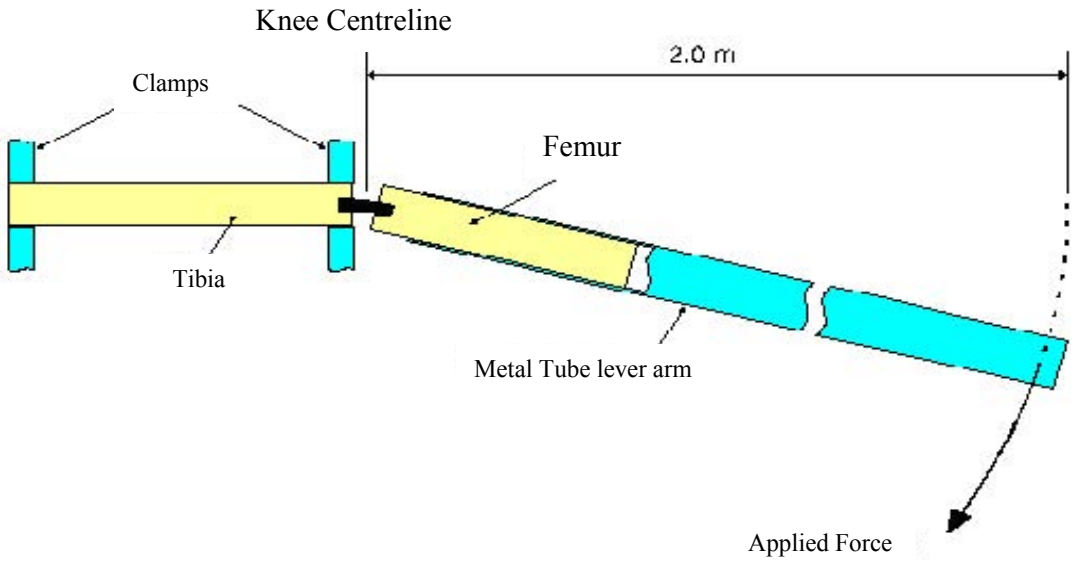


Figure 20

Top View of Test Set-up for Static Lower Legform Impactor Bending Certification Test

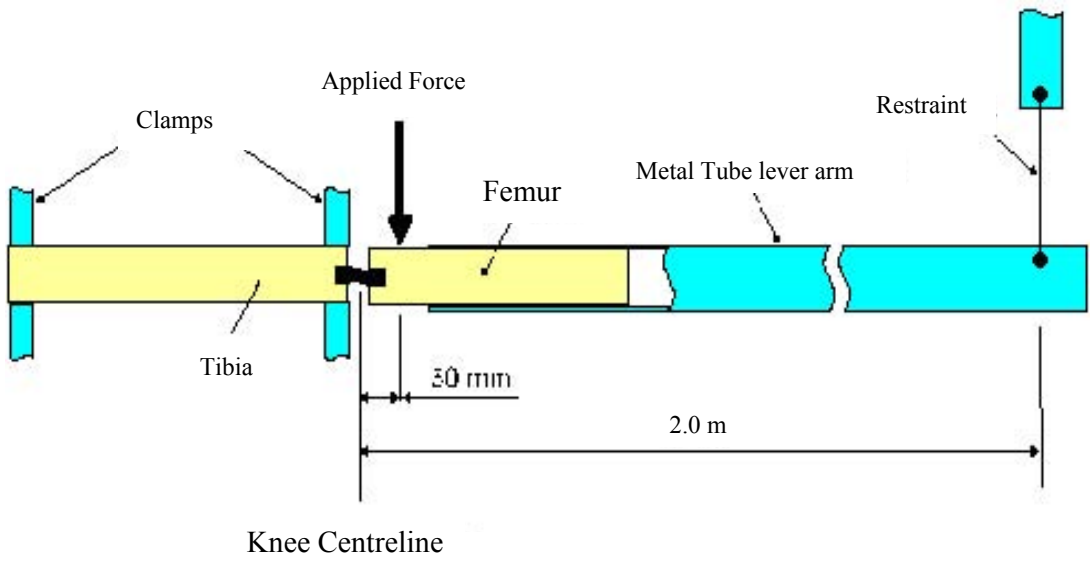
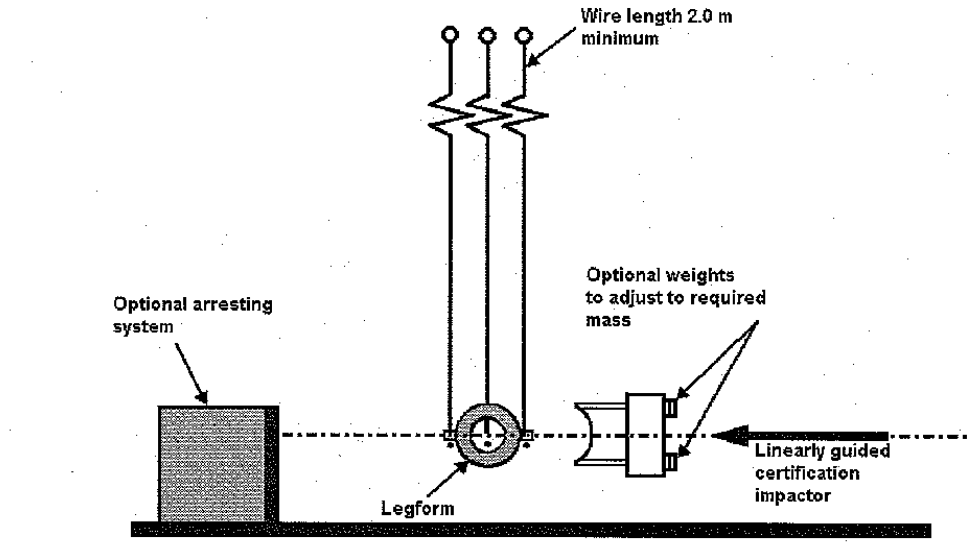
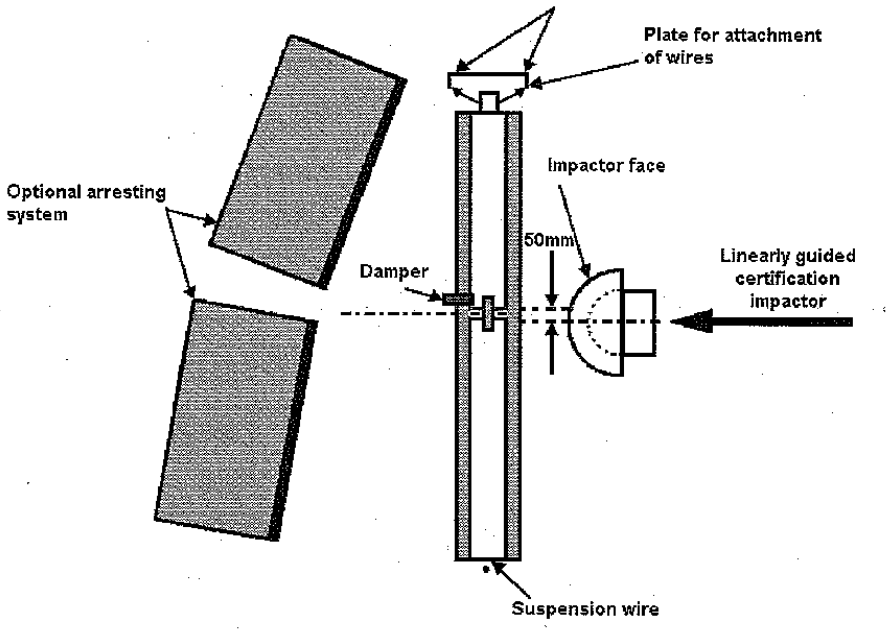


Figure 21

Top View of Test Set-up for Static Lower Legform Impactor Shearing Certification Test



Side View



Top View

Figure 22

Test Set up for Dynamic Lower Legform Impactor Certification Test

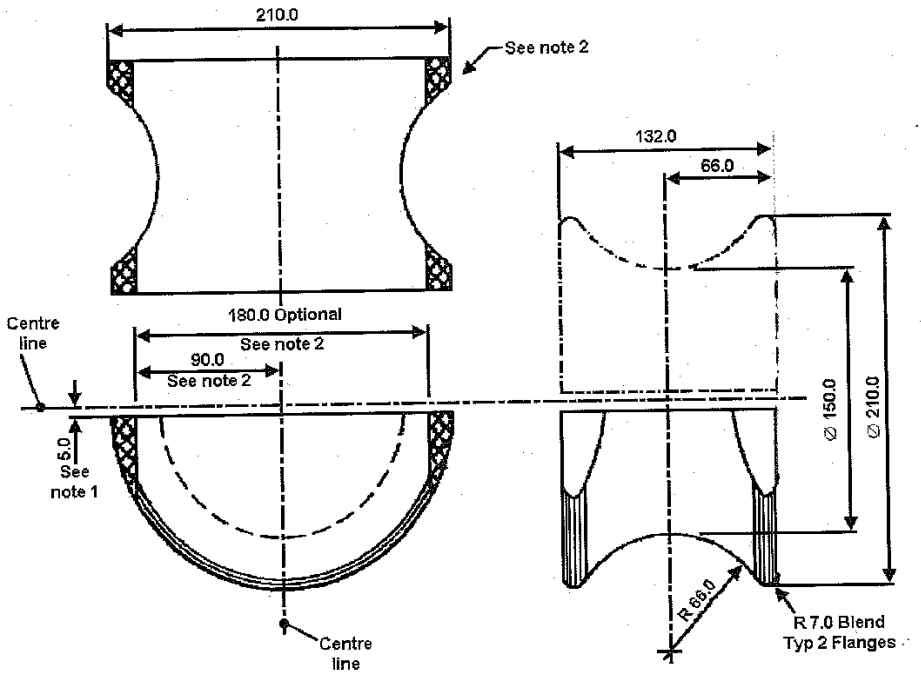


Figure 23

Details of Dynamic Lower Legform Certification Impactor Face

Notes:

1 Saddle may be made as a complete diameter and cut as shown to make two components.

2 The shaded areas may be removed to give the alternative form shown.

3 Tolerance on all dimensions is ± 1.0 mm.

Material: Aluminium alloy

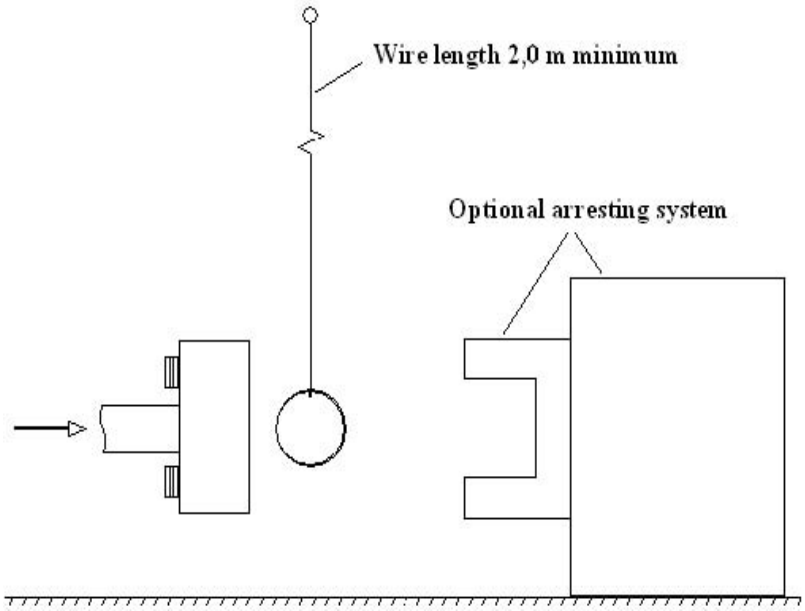


Figure 24

Test Set Up for Dynamic Upper Legform Certification Test

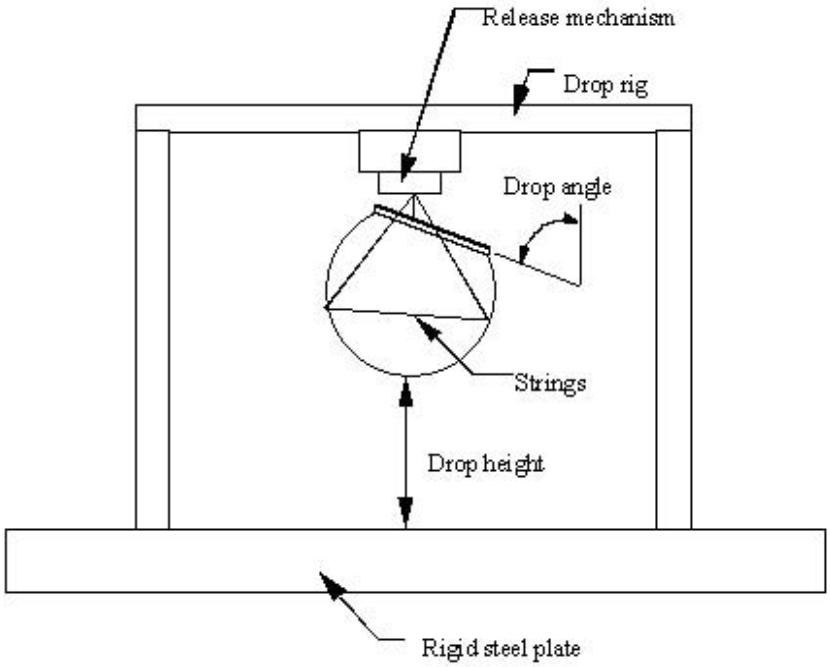


Figure 25

Test Set Up for Dynamic Headform Impactor Bio Fidelity Test

9 APPLICATION FOR APPROVAL

9.1 The application for approval of a vehicle type with regard to the protection of the pedestrian & vulnerable road users in the event of a collision with the motor vehicle shall be submitted by the vehicle manufacturer or by his duly accredited representative.

9.2 The application for approval must be accompanied with the information listed in Annex A.

9.3 A complete vehicle representative of the type to be approved shall be submitted to the Test Agency responsible for conducting the approval test. It should accompany sufficient quantity of the parts which would require replacements during the tests such as :

9.3.1 Bonnets,

9.3.2 Head lamps,

9.3.3 Bumpers, grills, bezels & energy absorbing structures if any,

9.3.4 Windshield wiper systems,

9.3.5 Engine covers,

9.3.6 Affected under bonnet fitments,

9.3.7 Actuators for active protection systems,

10 APPROVAL

10.1 If the vehicle type submitted for approval pursuant to this standard meets the requirements of Paragraph 5 above, approval of that vehicle type shall be granted.

10.2 In case of doubt, account shall be taken, when verifying the conformity of the vehicle to the requirements of this standard, of any data or test results provided by the manufacturer which can be taken into consideration in validating the approval test carried out by the testing agency.

11 MODIFICATIONS AND EXTENSION OF APPROVAL OF THE VEHICLE TYPE

11.1 Any modification of the vehicle type, with regards to protection of pedestrian in the event of a collision with a motor vehicle, shall be notified to the test agency which granted the approval. The test agency may then either:

11.1.1 consider that the modifications are unlikely to have any appreciable adverse effect and that in any case the vehicle still conforms to requirements. while deciding this, guidelines explained in Annex B shall be followed;

or

11.1.2 Require a further test report.

11.2 In case of 11.1.2, tests for only those parameters which are affected by the modifications shall be carried out.

11.3 In case of fulfillment of criteria of para. 11.1.1 or after successful results of further verification as per para 11.1.2 , the approval of compliance shall be extended for the changes carried out.

12 CRITERIA FOR SELECTION OF WORST CASE AND EXTENSION OF APPROVALS

The purpose of the paragraph is to set out guidelines for selection of the worst case configuration among the many configurations being approved within a vehicle type and to identify criteria for extensions of approval which may help the testing agency under 11.1. The guidelines are tabulated in Annex B.

12.1 Any other parameter can be considered as criteria for extension of approval if it is mutually agreeable to the testing agency & the vehicle manufacturer.

ANNEX A

(See 9.2)

INFORMATION TO BE PROVIDED WITH APPLICATION FOR TYPE APPROVAL OF A VEHICLE WITH RESPECT TO PEDESTRIAN PROTECTION

A.1 The following information and list of contents, if applicable, must be supplied.

A.2 If the systems, components or separate technical units have electronic controls, information concerning their performance must be supplied.

A.3 **GENERAL**

A.3.1 Make (trade name of manufacturer):

A.3.2 Type and general commercial description(s):

A.3.3 Category of vehicle (as per AIS-053):

A.4 **GENERAL CONSTRUCTION CHARACTERISTICS OF THE VEHICLE**

A.4.1 Unladen Kerb mass of the vehicle & its distribution over the axles :

A.4.2 Photographs and/or drawings of a representative vehicle:

A.4.3 Position and arrangement of the engine:

A.4.4 Details of the position of references on the vehicle structure which defines the normal ride attitude of the vehicle as per the condition defined in cl. 2.20.

A.5 **BODYWORK**

A.5.1 Type of bodywork:

A.5.2 Materials used and methods of construction:

A.5.3 Pedestrian protection:

A.5.4 A detailed description, including photographs and/or drawings, of the vehicle with respect to the structure, the dimensions, the relevant reference lines and the constituent materials of the frontal part of the vehicle (exterior) & mounted components shall be provided. This description should include detail of any active protection system installed.

ANNEX B

(See 11.1.1)

GUIDELINES FOR SELECTION OF PEDESTRIAN IMPACTOR TESTS FOR CHANGE IN THE VEHICLE TYPE

Parameter	Change	Test not required
B.1 Bumper design	Change in the bumper material,	Headform tests
	Change in bumper profile	
	Change in the bumper cross section	
	Change in the gap behind the bumper	
B.2 Bonnet design	Change in the bonnet material	Legform tests
	Change in the underbonnet gaps beyond WAD 1000	
B.3 Change in wrap around distance lines	WAD 1000 moved rearwards more than 82.5 mm	Legform tests

ANNEX C

(See Introduction)

COMPOSITION OF AISC PANEL *

Automotive Industry Standards Sub Committee on Pedestrian safety

Sr	Name & Designation	Representing
	Convener	
1	Mr. S. Ravishankar, Vice President	Tata Motors Ltd.
	Members	
2	Mr. A. V. Mannikar, Deputy Director	Automotive Research Association of India
3	Mr. S. Arun, Sr. Manager	Ashok Leyland
4	Mr. K. N. D. Nambudiripad, Advisor	Automotive Component Manufacturer's Association (ACMA)
5	Mr. V. M. Manel, Sr. Manager	Bajaj Auto Ltd
6	Mr. S. S. Kshirsagar, Sr. Manager	Bajaj Auto Ltd
7	Mr. D. P. Saste, Scientist "E"	Central Institute for Road Transport
8	Mr. R. M. Kanitkar, Chief Engineer	Force motors Ltd.
9	Mr A. V. Kumbhar, Manager	Force motors Ltd.
10	Mr. Neeraj Gupta, Div. Manager	General Motors
11	Mr Saleem Mohammad, EGM	General Motors
12	Mr. V. Sankaran, Gen. Manager	General Motors
13	Mr. S. K. Kalia, Sr Asst Director	ICAT, Manesar
14	Mr. Z. A. Mujawar, Gen. Manager	Mahindra & Mahindra
15	Mr. M. M. Paradkar, Manager	Mahindra & Mahindra
16	Mr Jitendra Malhotra, Sr. Manager	Maruti Suzuki Ltd.
17	Mr. Sourabh Gupta, Asst. Manager	Maruti Suzuki Ltd.
18	Mr. Pankaj Karn, Asst. Manager	Society of Indian Automotive Manufacturers (SIAM)
19	Mr. Prakash Vemali	Mercedes Benz India Ltd
20	Mr. Tarun Nagar	Mercedes Benz India Ltd
21	Mr. C. Anilkumar, Project Manager	Tata Motors Ltd.
22	Mr. V. S. Gogate, Project Manager	Tata Motors Ltd.
23	Mr. S Sakthivelan, Manager	Toyota Kirloskar Motors Ltd.
24	Mr. M. Raju, Engineer	Toyota Kirloskar Motors Ltd.
25	Mr. Sumit Sharma, Sr. Manager	Volkswagen

* At the time of approval of this Automotive Industry Standard (AIS)

ANNEX D

(See Introduction)

COMMITTEE COMPOSITION *

Automotive Industry Standards Committee

Chairman	
Shri Shrikant R. Marathe	Director The Automotive Research Association of India, Pune
Members	**Representing**
Representative from	Ministry of Road Transport & Highways (Dept. of Road Transport & Highways), New Delhi
Representative from	Ministry of Heavy Industries & Public Enterprises (Department of Heavy Industry), New Delhi
Shri S. M. Ahuja	Office of the Development Commissioner, MSME, Ministry of Micro, Small & Medium Enterprises, New Delhi
Shri T. V. Singh	Bureau of Indian Standards, New Delhi
Director Shri D. P. Saste (Alternate)	Central Institute of Road Transport, Pune
Dr. M. O. Garg	Indian Institute of Petroleum, Dehra Dun
Dr. C. L. Dhamejani	Vehicles Research & Development Establishment, Ahmednagar
Representatives from	Society of Indian Automobile Manufacturers
Shri T.C. Gopalan	Tractor Manufacturers Association, New Delhi
Shri K.N.D. Nambudiripad	Automotive Components Manufacturers Association of India, New Delhi
Shri Arvind Gupta	Automotive Components Manufacturers Association of India, New Delhi

Member Secretary
Mrs. Rashmi Urdhwareshe
Deputy Director
The Automotive Research Association of India, Pune

* At the time of approval of this Automotive Industry Standard (AIS)